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FUTURE MEETINGS of the AMERICAN INSTITUTE of ELECTRICAL ENGINEERS

Place	Date	Nature	Manuscript Closing Date
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	(Closed)
Schenectady, N. Y.	May 10-12, 1933	District Meeting	Feb 10, 1933
Chicago, Ill.	June 26-30, 1933	Summer Convention	March 26, 1933
Salt Lake City, Utah	Aug.-Sept. 1933	Pacific Coast Convention	May-June 1933

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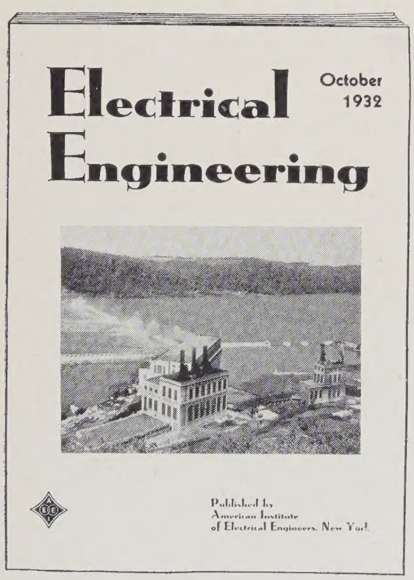

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This Month—*Winter Convention Issue*

Front Cover

Electricity in industry as seen by the photographer.
Photo by Joseph B. Wertz, New York, N. Y.

—Turn to Next Page

NOMINEES for 1933–34 Institute officers were announced recently by the A.I.E.E. national nominating committee. *p. 56; 60–3*

CORRECTIONS—On p. 854 of ELECTRICAL ENGINEERING for December 1932, Fig. 3 inverted. On p. 856, top and third from top charts of Fig. 3, scale marking "15 mm" should read "15 min."

ALTERNATING current of relatively high frequency is claimed to be better than direct current for electric arc welding; a 900-cycle inductor alternator capable of supplying several arcs simultaneously has been developed. *p 14–16*

ELECTRICAL equipment is being used most successfully in pumping oil and petroleum products through long pipe lines; within the last few years large electric motors totaling more than 180,000 hp have been applied to that service. *p. 29–34*

COMMUNICATION systems of railroads is a subject to which an entire session has been assigned at the forthcoming A.I.E.E. winter convention. The opening paper of that session is published outlining the general requirements for modern American roads. *p. 11–14*

IN AN EFFORT to standardize impulse voltage testing of electrical apparatus, the A.I.E.E. lightning and insulator subcommittee has recommended a set of preferred test waves; the transformer subcommittee has agreed upon a tentative test procedure for transformers. *p. 9–11; 17–22*

ECONOMIC and social results of the use of automatic and supervisory control on the power supply of a middle western street railway system have been analyzed from the point of view of the executive. The net effect on the car-rider evidently has been "to remove the power supply part of the system from his consciousness." *p. 22–28*

FINAL plans for the 1933 A.I.E.E. winter convention to be held in New York City, January 23–27, are nearly complete. Those attending will have an opportunity to hear and discuss more than 50 technical papers and to participate in the variety of social events and inspection trips that have been arranged. *p. 53–4.* Essentially full text of 8 of the leading papers to be presented is included in this issue, as well as abstracts of all others approved at the time of going to press. *p. 41–52*

Higher Steam Pressures and Temperatures

A Challenge to Engineers

By
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Both of
The Edison Elec. Illum.
Co. of Boston, Mass.

Here is given a résumé of the accomplishments to date in the long-continued efforts toward ever-improved operating economy in steam-electric generating stations. Facts seem to indicate that the engineers of the future will meet the challenge of past accomplishments by building stations of still higher fuel economy and still lower cost per unit of capacity.

THE OPTIMUM steam pressure and temperature for steam-electric generating stations has not been determined. Because of the importance of the subject to the electrical industry, it has been considered worth while to present a résumé of what has been accomplished with comments of such a nature as to provoke helpful discussion.

Operating pressures and temperatures that have been used in the steam-electric generating stations of one of the electrical companies in the United States from 1885 to date are shown in Fig. 1, and in Fig. 2 is shown the improvement in fuel economy that has resulted from the use of higher steam pressures and temperatures and other improvements in the design of the stations of the same company. These curves are typical of what has been accomplished by the electrical industry in general by constant and persistent study of the problem. The second curve in Fig. 2 shows what has been accomplished by all utility plants in the United States—good, bad, and indifferent. These curves indicate that the fight for better economy has been very much worth while, but at the same time they challenge to the ingenuity of the engineers of the future. This ever improved fuel economy has been accomplished in general by stations that have cost less and less per unit of capacity in spite of their better economy. Will the engineers of the future be able to meet the challenge?

The comparison or approximate station heat rates, with pressure constant and temperature varying from 750 to 1,000 deg F, given in Fig. 3 shows graphically that no matter what pressure or cycle may be selected, the higher the steam temperature, the better the station economy. Most of the problems involved in the use of a steam temperature of 750 deg F have been solved. Some of the new stations now being built will operate at temperatures of from 825 to 850 deg F, and within a comparatively few years plants undoubtedly will be operating with steam temperatures of 1,000 deg F. Since the limitations imposed by the materials used in the construction of superheaters, reheaters, turbines, valves, and other such equipment slowly are being removed and the 1,000 deg F station no longer is a fantastic dream; it will be a reality within the lifetime of many of those living today.

The problem of controlling the temperature of

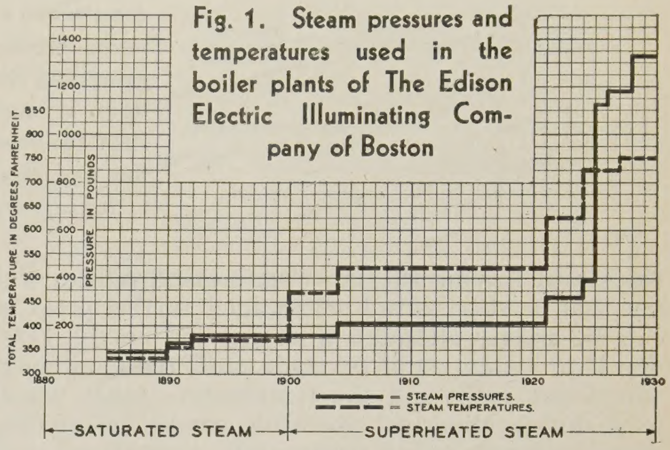


Fig. 1. Steam pressures and temperatures used in the boiler plants of The Edison Electric Illuminating Company of Boston

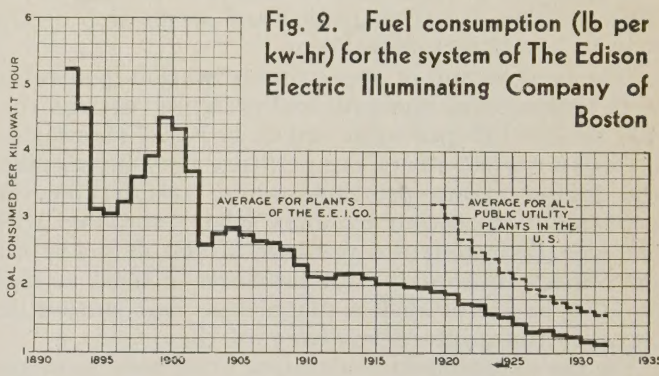


Fig. 2. Fuel consumption (lb per kw-hr) for the system of The Edison Electric Illuminating Company of Boston

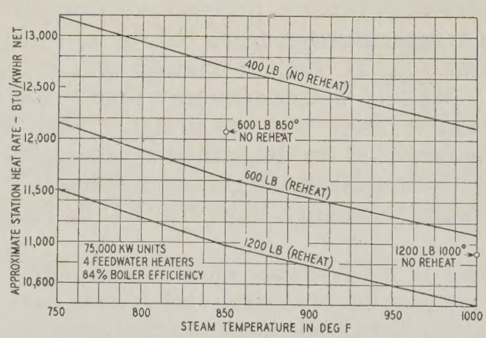


Fig. 3. Comparison of approximate station heat rates at constant pressure and varying temperature

Full text of a paper (No. 33-19) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

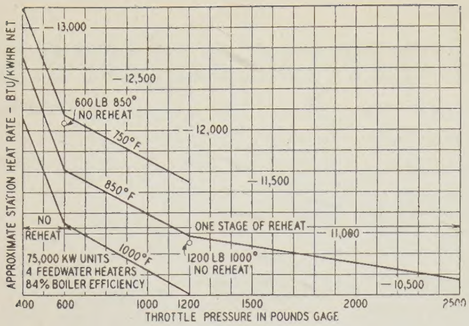


Fig. 4. Comparison of approximate station heat rates at constant temperature and varying pressure

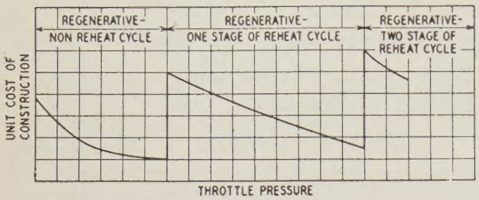


Fig. 5. Probable variation in unit cost of construction of steam-electric generating stations at constant temperature and varying pressure

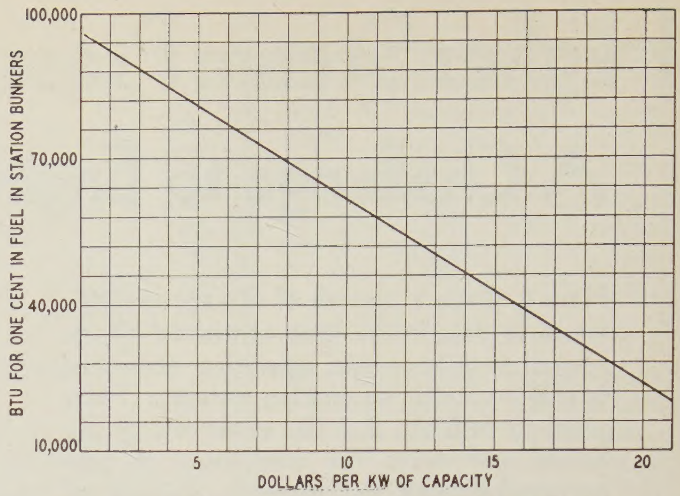


Fig. 6. Additional capital investment justified for 1,200-lb 750-deg stations as compared to 400-lb 750-deg stations

the steam leaving the superheaters and reheaters is one that must be solved before much further progress can be made, although a design for nearly 1,000 deg F probably could be made now, the equipment would not withstand the temperature that would exist during abnormal operating conditions such as dirty boilers, poor combustion conditions, and changes in the character of the fuel being burned. This problem is being studied and seems well on the way to a satisfactory solution.

The comparison of approximate station heat rates, with temperature constant and pressure varying from 400 to 2,500 lb per sq in., given in Fig. 4 shows that no matter what steam temperature may be selected, the higher steam pressures show considerable improvement in station economy when compared with the so-called moderate pressure of 400 lb. The improvement in economy for pressures at least as high as 1200 lb are of such a magnitude that station designers cannot afford to disregard them.

On the plea that such a station gives good economy and is simpler than one employing the reheat cycle, some designers seem to favor a pressure of from 600 to 700 lb and a temperature of from 825 to 850 deg F without reheat. That such a station will give approximately 5 per cent better economy than a 400-lb 850-deg station is true, but the designer should not overlook the fact that on the same basis a 1,200-lb 850-deg reheat cycle station will give approximately $13^1/_2$ per cent better economy than the 400-lb 850-deg station.

Several stations now in service employ the reheat cycle and no very serious operating difficulties have shown up. The problem boils itself down, therefore, to the question of the unit cost of construction for stations of various pressures and cycles.

Where the only difference is to be in the steam pressure or steam temperature, the advance determination of the exact comparative cost of a new station or an extension to an old station is an extremely difficult matter. The difference in unit cost is a very small percentage of the whole, and an error in design can change the unit cost more than the

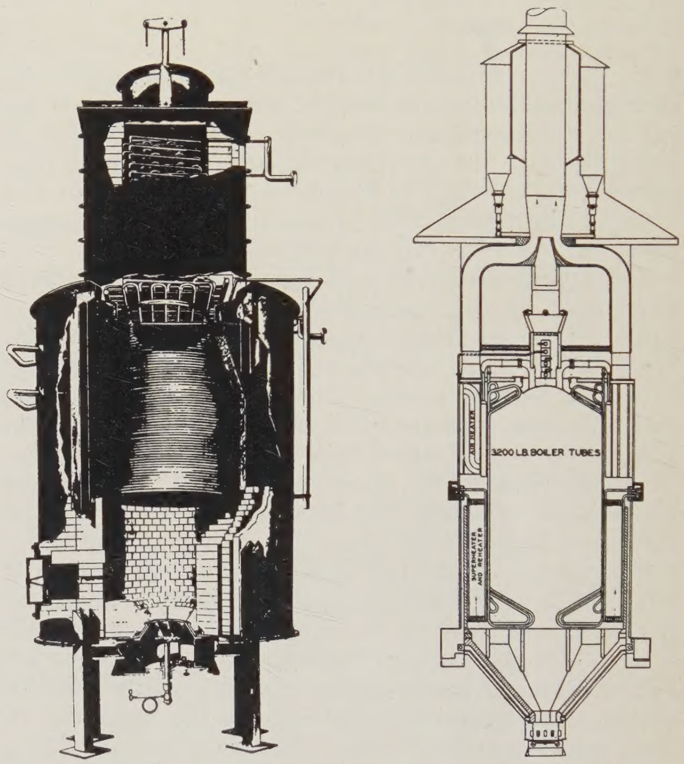


Fig. 7. Series boilers—(left) experimental installation at Purdue University; (right) Benson boiler as commercially installed in Europe

difference due to pressure or temperature. Because of the other variables entering into the various designs, those who actually have built stations for moderate and high pressures are not really sure as to the exact difference in unit cost. However, all those who have built high pressure stations believe that the higher pressure was justified.

Past experience has shown in general that higher steam pressure does not of itself increase the cost of construction, but actually results in lower unit costs of construction. For example, probably all agree that a 400-lb 750-deg non-reheat station would cost less per kilowatt of capacity than a 200-lb 750-

deg station built to operate on the same cycle. It is known, however, that a 600-lb 750–750-deg reheat station would cost more per kilowatt of capacity than a 600-lb 750-deg non-reheat station.

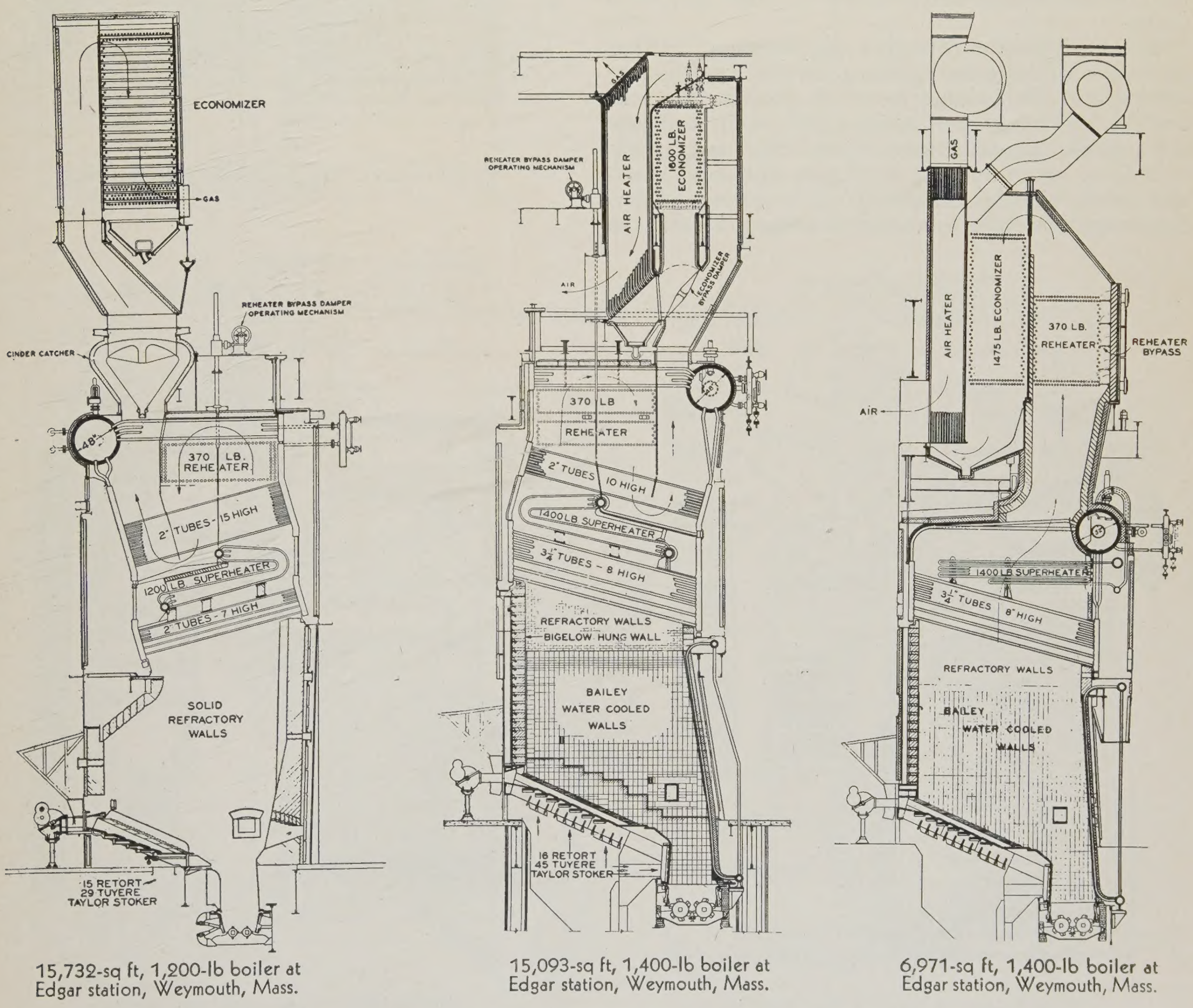
The probable facts of the case are that the unit cost of construction decreases with increase in pressure as long as the same heat cycle is employed and as long as the pressure does not require a radical change in the design of the pressure apparatus. When a pressure is reached that requires a change in the heat cycle or a radical change in design of the pressure apparatus, the unit cost probably takes a sudden jump, to fall off again as the pressure is increased to the point where another change in heat cycle or design is necessary. This idea is illustrated graphically by Fig. 5.

The unit cost of the pressure parts is greater for higher pressure apparatus, and hence high pressure mistakes are more expensive than low pressure mistakes. This discussion assumes proper design for all conditions.

The additional capital investment per unit of capacity that is justified for a 1,200-lb 750–750-deg reheat station over a 400-lb 750-deg non-reheat station for 40 per cent load factor and various costs of fuel is indicated in Fig. 6. When there is in mind a question as to the exact unit cost of the high pressure station, it is comforting to know that a considerable increase in unit cost is justified by the higher thermal efficiency.

We all are interested in generating electrical energy for the lowest cost per net kilowatt-hour; also in keeping to a minimum the cost per net kilowatt of capacity of our generating stations. We would be untrue to our trust, however, if we did not design according to our best engineering judgment so as to obtain the lowest cost per net kilowatt-hour generated. We should endeavor to obtain the highest possible "dollar efficiency."

Another important consideration in the selection of the most economical pressure and temperature is the fact that the design and manufacture of high pressure generating equipment is in its infancy. As time goes on, designs will be improved and manufacturing methods will be changed so that the installation of the more economical equipment will be pos-



15,732-sq ft, 1,200-lb boiler at Edgar station, Weymouth, Mass.

15,093-sq ft, 1,400-lb boiler at Edgar station, Weymouth, Mass.

6,971-sq ft, 1,400-lb boiler at Edgar station, Weymouth, Mass.

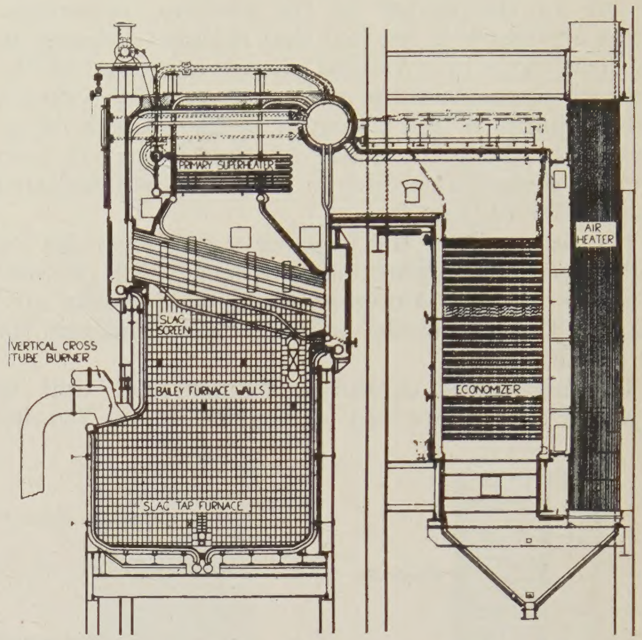
Fig. 8. Sections through boiler installations, revealing the trend of development

sible for considerably less cost per unit of capacity than prevails today. A period of development, however, is necessary. If, by the use of equipment that is economically justified at its present price, we can promote this development without actual financial loss, we aid in the progress of the art and will reap even greater profits in the future. If we refuse to install the equipment that our engineering studies indicate to be the most economical, we are seriously hindering the progress of our industry.

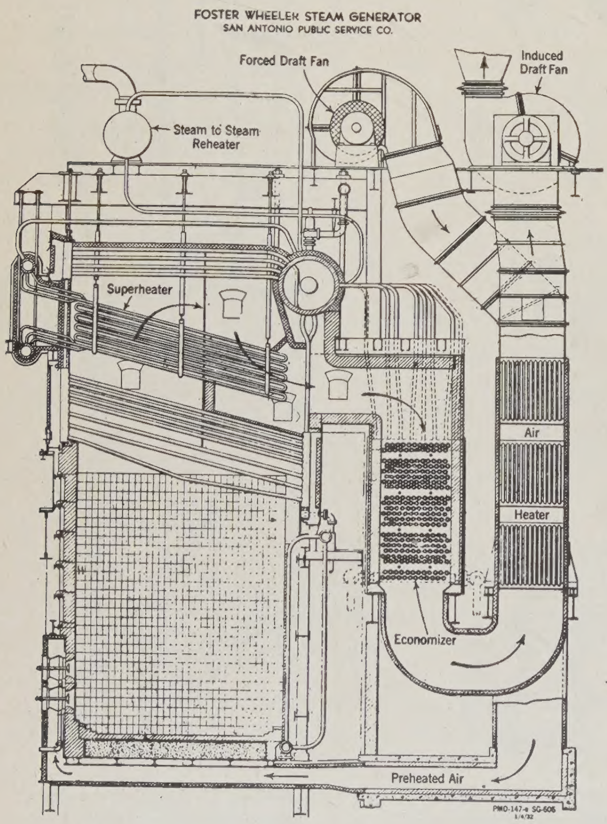
Station designs in which one steam producing unit supplies all the steam required by one turbine-generator unit are becoming more and more generally accepted as being the most economical. A properly designed steam producing unit has about the same availability today as the turbine-generator units and this change in design is both logical and justifiable. Furthermore, since the availability of the steam producing unit and turbine-generator unit are about the same, there seems to be no justification for spare steam producing units in a station. Stations built in the future can be expected to have firm boiler capacity very closely matching the full load steam requirements of the turbine generator units.

The welded boiler drum is a new development that probably will become more generally used in the future, and that should result in lowering the unit cost of the steam producing units. Only recently have boiler manufacturers made any serious attempts to determine the maximum safe capacity of the boilers they manufacture. This information is necessary if the most economical design of boiler is to be obtained. The boiler units of the future probably will be designed to operate the boiler proper at nearly its maximum safe capacity; heat traps of various kinds will be so arranged as to give the boiler room the efficiency that is justified under the particular conditions of the installation.

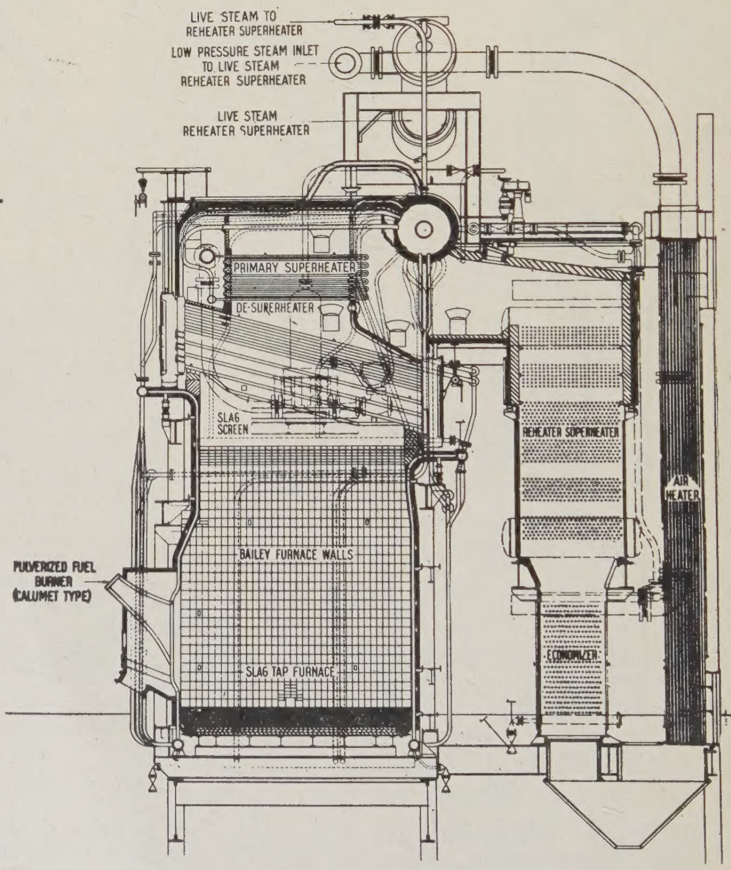
Where its use is possible, it should not be forgotten



1,400-lb boiler at State Line station, Hammond, Ind.



1,525-lb boiler at Station B, San Antonio, Texas



1,400-lb boiler, South Amboy (N. J.) station

Fig. 9. Sections through boiler installations, revealing the trend of development

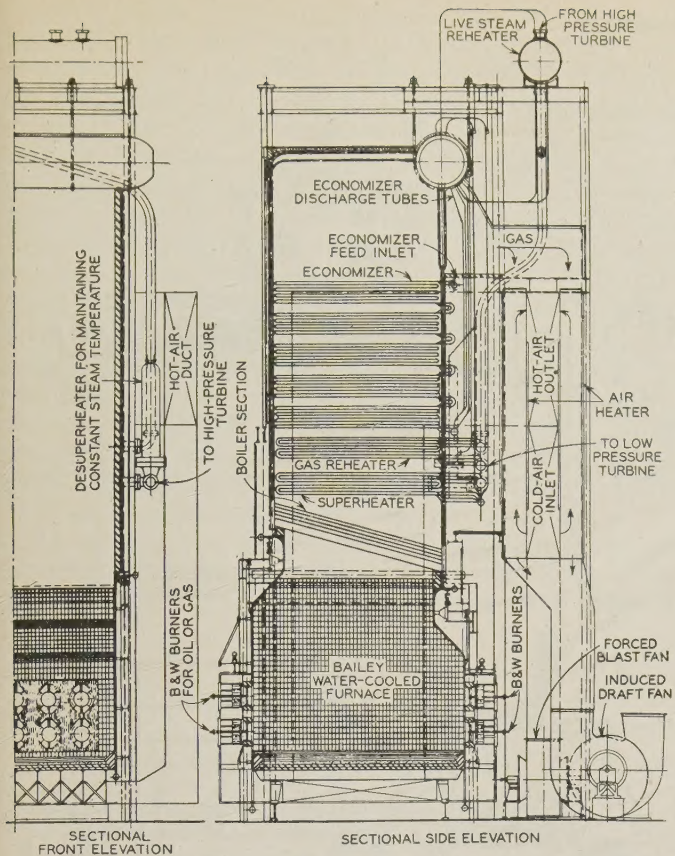


Fig. 10. Cross-section of proposed 1,400-lb boiler, having a capacity of 25,000 lb per hr per section

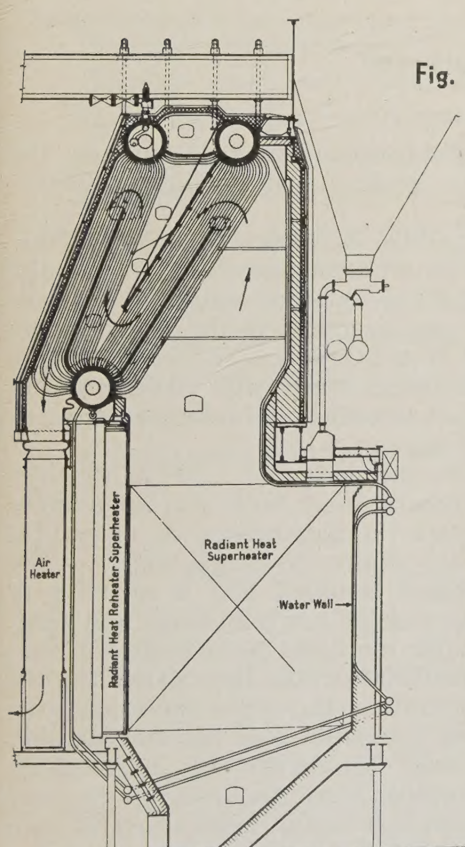
that the most economical boiler design is one using the longest drums obtainable and the longest tubes that will fit in with the particular design. Such a design not only results in the lowest cost of the boiler itself, but also gives the lowest unit cost of building, furnace, and practically all items that enter into the cost of the boiler plant.

The series boiler (Fig. 7) has been in use for several years in Europe, and the manufacturer claims that such a design results in the lowest unit cost. Recently there has been considerable interest shown in this type of boiler in the United States, and two experimental units have been built and tested. The possibilities of this type of steam producing unit warrants further study, and probably commercial trial in the United States. In spite of a natural prejudice against the idea in general and the many reasons that can be thought of to show why such apparatus would be unsatisfactory, that such equipment now is in service in Europe and operating with some degree of success. The series boiler and superheater may be the answer to the need in the United States for superheat control for higher temperatures, and may have possibilities not recognized at this time.

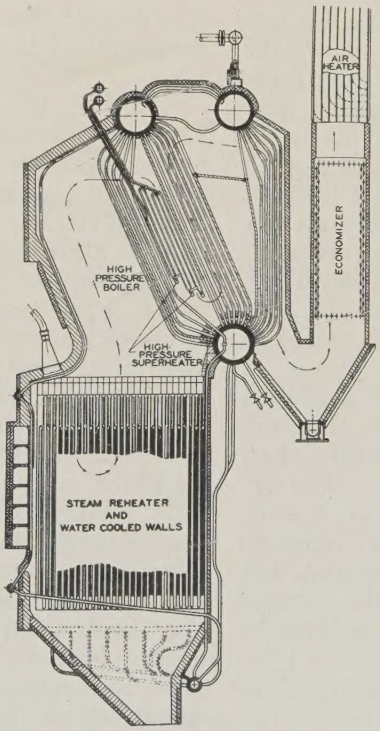
The use of larger and larger turbine-generator units in the past has resulted, in general, in a satisfactory reduction in the unit cost of the units, their auxiliaries, and the building to house them. Probably larger units will be used in the future than are dreamed of today.

Manufacturers of turbine generators have patterns for turbine shells of various sizes and, when

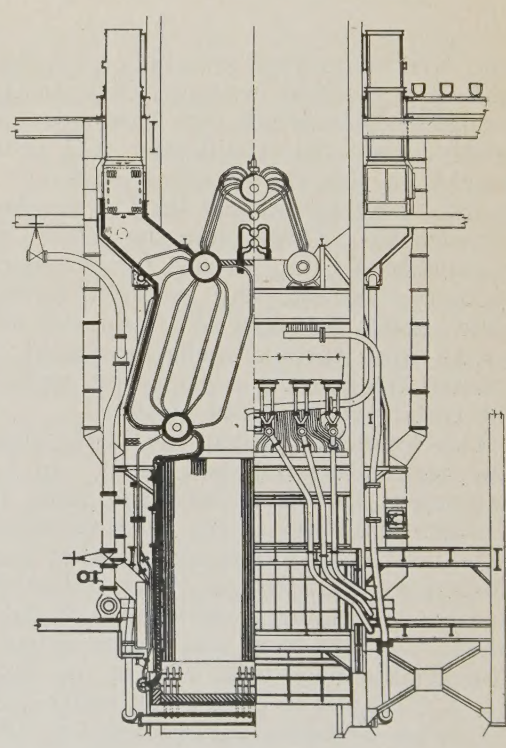
Fig. 11. Sections through boiler installations, revealing the trend of development



1,300-lb boiler at Lakeside station, Milwaukee, Wis.



1,350-lb boiler at Northeast station, Kansas City, Mo.

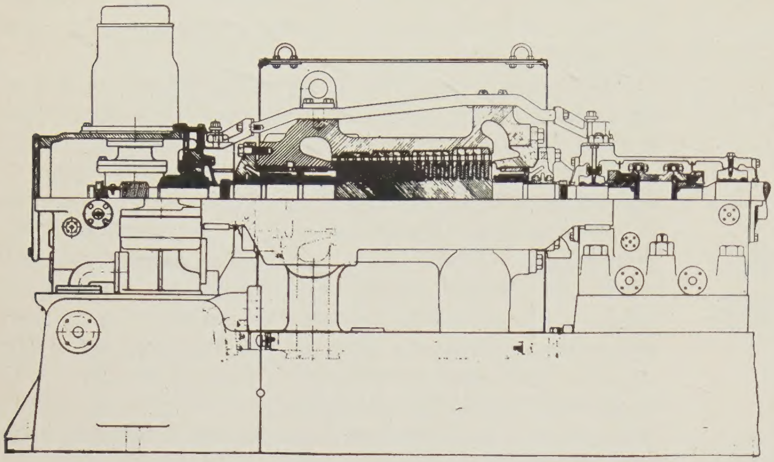


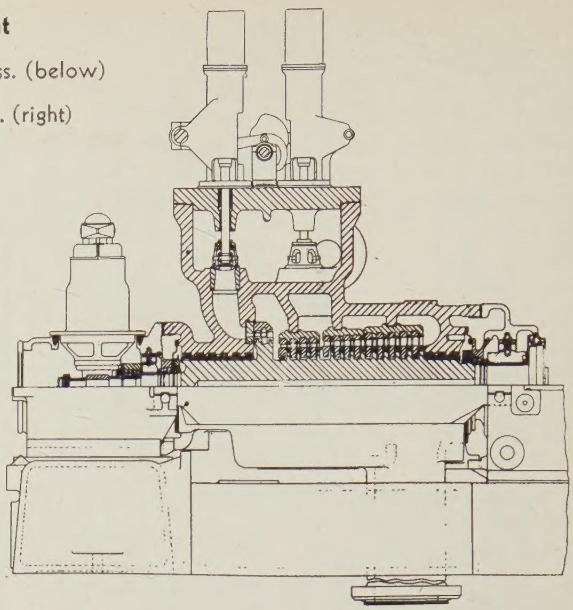
1,400-lb boiler at River Rouge plant, Detroit, Mich.

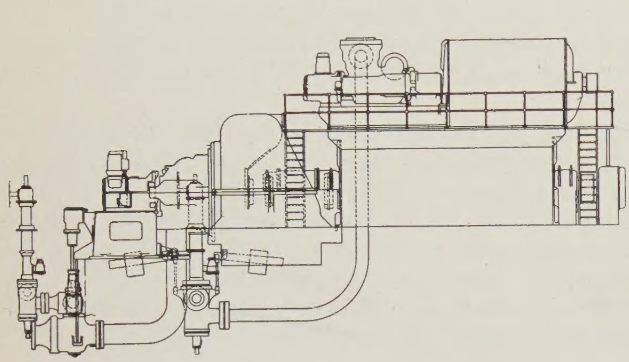
Fig. 12. Illustrating the trend in steam turbine development

20-stage single-valve 3,150-kw 1,200-lb turbine at Edgar station, Weymouth, Mass. (below)

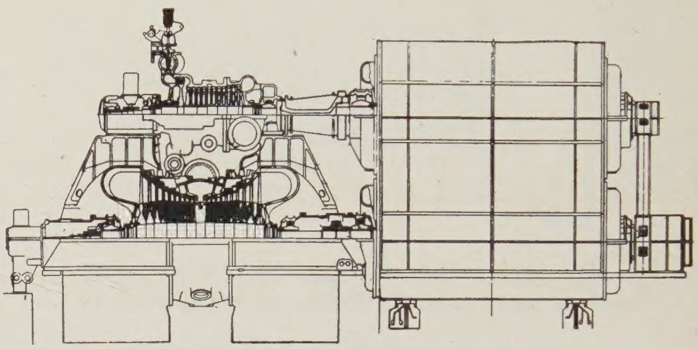
5-valve 12,500-kw 1,200–1,300-lb turbine at Edgar station, Weymouth, Mass. (right)







50,000-kw vertical compound turbine generator



110,000-kw vertical compound turbine generator at River Rouge plant

Fig. 13. Illustrating the trend in steam turbine development

they receive a request for a bid on a turbine-generator unit of a specified capacity, they usually select the turbine shell for which they have a pattern that most nearly meets the specification and provide it with nozzles to suit the specified capacity. This is, of course, more economical than to design a new shell for each bid. Quite often the turbine shell selected is capable of being nozzled for considerably greater capacity, without any material increase in cost. Care should be taken to obtain the maximum capacity from turbine shells purchased, for in that manner the greatest capacity per dollar invested in the turbine room can be obtained.

Development of apparatus for the higher pressures has been interesting and rapid. In fact, 1,200-lb equipment has been developed more rapidly than equipment for any of the lower pressures. The designs used have shown clearly what can be accomplished by intensive study by competent engineers and by close cooperation between manufacturers and users. In Figs. 8, 9, and 10 are shown the various designs that have been used in the development of the 1,200–1,400 lb cross-drum boiler, from the 143,000-lb-per-hr boiler installed in the Edgar Station, Weymouth, Mass., (capacity approximately 3,575 lb per hr per section) to the latest design offered (capacity approximately 25,000 lb per hr per section). A study of the illustrations will reveal clearly the development of the apparatus; discussion is unnecessary.

Likewise, the parallel development of the 1,300–1,400-lb multiple-drum bent-tube boiler, from the first one installed in the Lakeside station in Milwaukee to the latest ones installed in the River Rouge Plant of the Ford Motor Company in Detroit, shown in Fig. 11 reveals progress although the changes in design have not been as radical as in the development of the cross-drum type.

Developments in the design of 1,200-lb turbines and boiler feed pumps have been correspondingly satisfactory although the illustrations do not reveal the changes so clearly as they do for the boilers. The first 1,200-lb turbine installed had a capacity of 3,150 kw and was a single-valve 20-stage unit (Fig. 12). Several similar machines were built with capacities as great as 10,000 kw, but they all had the disadvantage that because of the single valve construction their economy at partial load was considerably less than at full load. To rectify this shortcoming, multiple valve turbines were designed, giving very good economy from half to full load. Several such turbines have been installed and are performing satisfactorily (Fig. 12).

Another interesting development has been the so-

called vertical compound design (Fig. 13) in which the high pressure turbine and its generator are mounted above the low pressure element, resulting in a considerable saving in foundations and floor space. The largest 1,200-lb turbine generator in service today has a capacity of 110,000 kw, but others of larger capacity are under construction. Development of the high pressure boiler feed pump also has been rapid from the first 300-gpm unit to later ones having a capacity of 2,000 gpm or more. The difficulties in evolving satisfactory high pressure boiler feed pumps have been accentuated by the lack of suitable variable speed 3,600-rpm a-c motors and by the fact that the water is heated by the extraction heaters to a temperature of about 440 deg F. These two factors and the difficulty of obtaining sound steel castings have been responsible for most of the difficulties that have shown up.

In making the decision on the steam pressure to be used in future construction, the fact that much greater capacity can be installed on a given piece of property if the station is designed for the higher pressures also should be kept in mind. If the circulating water available is limited, or the cost of constructing the intake and discharge is high because of local conditions, the high pressure station has the advantage that greater capacity can be obtained from the water available; hence the unit cost of the intake and discharge tunnels will be considerably less.

Where existing stations are to be remodeled or extended, high pressure equipment will permit greater capacity to be installed in existing buildings, can be given load preference, and will increase the economy of the whole station much more than the difference in economy between the high pressure equipment and the existing equipment.

From a consideration of these facts, it can be said safely that the engineers of the future will meet the challenge of past accomplishments, and will build steam-electric generating stations that not only will show still better fuel economy than present stations, but also will cost less per unit of capacity.

Impulse Testing of Commercial Transformers

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The transformer subcommittee of the A.I.E.E. electrical machinery committee presents herewith a progress report covering its work to date on the impulse voltage testing of commercial electric power transformers. A tentative test procedure has been agreed upon, although complete agreement has not yet been reached on all details. It is hoped that this report will stimulate among members of the Institute discussion that will be helpful to the committee in completing a formal test code during the coming year.

AT THE A.I.E.E. winter convention in January 1932, the electrical machinery committee of the Institute assigned to the transformer subcommittee the task of determining the feasibility of impulse voltage tests on commercial transformers and of making recommendations for such tests, if possible. Agreement has been reached on a tentative test procedure, although complete agreement has not yet been reached on all details.

One of the first questions considered was the possibility of detecting impulse voltage failures. Transformers in service show the effects of insulation failure only by their inability to deliver power and by the formation of power arcs within the windings. For this reason, the combination of normal frequency excitation with impulse tests was carefully considered, since with this arrangement service conditions are duplicated and a transformer withstanding a test of this kind reasonably might be expected to stand up in service. Considerable experience with such a method already had been obtained when the subcommittee undertook this study, and the results of this experience appeared favorable; the subcommittee therefore devoted its efforts to the development of a practical test procedure along this line.

The purpose of making impulse tests on a transformer is to give a reasonable demonstration that the transformer has met the specification requirements as to impulse strength. The low frequency dielectric tests that have been used in the past cannot demonstrate this because the low frequency test voltage is of lower magnitude and is uniformly distributed throughout the winding, whereas the lightning voltage is generally of much higher magni-

Full text of a report (A.I.E.E. Paper No. 33-37) sponsored by the transformer subcommittee of the A.I.E.E. electrical machinery committee, to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

Transformer subcommittee—H. V. Putnam, *chairman;* G. M. Arbrust, E. S. Bundy, J. E. Clem, Basil Lanphier, H. C. Louis, A. C. Montieth, V. M. Montsinger, L. C. Nichols, E. D. Treanor, and F. J. Vogel.

tude and may depart radically from a uniform distribution. Impulse tests therefore will give a more adequate demonstration of the sufficiency of the insulation strength of transformers for service conditions.

Equipment Required for Testing

Impulse testing equipment (generator, discharge circuit, cathode ray oscillograph, and voltage divider) shall consist of only such parts and circuits as can be analyzed readily regarding the constants which have an appreciable effect upon the shape and amplitude of the voltage wave applied to the transformer under test. Such factors as the capacitance and inductance of the transformer under test, length of circuit from impulse generator to transformer, length of cable from divider to cathode ray oscillograph, length of main discharge circuit, as well as electromagnetic and electrostatic interference effects all must be taken into consideration. Testing technique and operation of the testing equipment should be that best suited for the purpose.

The equipment, in addition to that required for the producing and recording the waves, will consist generally of a source of power for exciting the transformer under test, means for synchronizing the impulse wave with the crest of the alternating voltage wave, a standard point gap, and means for limiting the power-follow across the gap. A technique of cathode ray oscillograph measurement should be developed for each test equipment so that the accuracy of the oscillograph and its potentiometer with respect to both time and voltage can be demonstrated.

The equipment should be located as closely together as possible. Nevertheless, it is necessary to provide sufficient space between all parts of the equipment so that there is no interference, and to provide for practical considerations. With this in mind, and to permit reasonable accuracy, it is recommended that the transformer terminals, coordinating or test gaps, and measuring equipment be within a range of less than 150 circuit feet.

Methods of Applying Tests

Constants of the surge generator should be adjusted so that the specified wave shape is obtained with the transformer connected. After the proper initial adjustments for the transformer under test are completed, changes in the test voltage can be made by varying the voltage applied to the surge generator, without requiring additional demonstration in regard to wave shape. Should the voltage applied to the transformer be changed by changing the constants of the circuit, it will be necessary, of course, to demonstrate the wave shape for the changed conditions.

The impulse wave should be applied with the transformer excited and with the wave synchronized at or within 30° of the crest of the excitation voltage. The 2 waves should be of opposite polarity at the time of synchronization, as this provides the severest test of the windings.

The test should be made on one terminal at a time. This simplifies test procedure, and generally will satisfy all requirements for a rigid test. Where series transformers for regulating purposes or other similar equipment require special protective devices, these should be in the circuit during the tests. During each test all bushings on windings not being tested will be either grounded or protected by appropriate means.

Type of Wave to Be Applied

The full wave will be satisfactory if it has a nominal front of from $^1/_2$ to $2^1/_2$ μsec, and a tail reaching half the crest voltage in from 40 to 50 μsec from the point on the front of the wave at which the voltage is 10 per cent of the crest voltage. The nominal front of the wave can be determined by measuring the time between points on the front at which the voltage is, respectively, 10 and 90 per cent of the crest value; this time divided by 0.8 will define the front of the wave. If there are oscillations on the front of the wave, the 10- and 90-per cent points should be determined from the average smooth wave front sketched in over the oscillations. The wave should be as smooth as possible because oscillations have the effect of increasing the stress on the winding under test. The wave shape should be recorded by the cathode ray oscillograph.

Tests to Be Applied

In all tests the transformer tank will be grounded directly and test gaps, where they are used, will be connected directly to the same ground. Each terminal of the transformer to be tested should be tested with waves of positive polarity having respectively:

1. A voltage not more than 10 per cent less than the minimum impulse voltage permitted by the specified test gap directly connected to ground.

2. A voltage just sufficient to flashover the specified test gap directly connected to ground.

3. A crest voltage at least 10 per cent greater than the minimum flashover voltage of the test gap directly connected to ground.

4. A voltage of sufficient magnitude to flashover the bushing.

5. A voltage as great as that specified in No. 3 or 4, but with means for maintaining the excitation voltage across all parts of the winding. The purpose of this requirement is to prevent short-circuiting the windings through the power follow over the gap or bushing immediately after the impulse, which would cause the dynamic voltage to collapse and thus prevent the detection of an internal failure.

It is recognized that these tests do not make any allowance for the effects of variations in humidity and relative air density, and may not provide tests of the desired severity. However, the transformer subcommittee is giving consideration to these matters.

The transformer bushing and test gap shall have a minimum flashover voltage at least 10 per cent greater than the minimum flashover voltage of the proposed standard A.I.E.E. coordination gaps. (See "The Coordination of Line and Transformer Insulation," V. M. Montsinger and W. M. Dann, Electrical Engineering, v. 51, June 1932, p. 390–1.)

To obtain this, test gaps as indicated in Table I will be used.

The Detection of Failures

Because of the nature of impulse voltage failures, one of the most important matters is the detection of failure. There are a number of positive indications of insulation failure. Some of these are: noise within the transformer; presence of smoke; excessive current or drop in voltage in the excitation circuit; failure of the gap or bushing to flashover when actually a sufficient surge voltage is applied; presence of oscillations or other variations from the expected wave shape as indicated by cathode ray oscillograms. These are positive indications of failure and will satisfy all practical requirements.

Table I—Test Gaps Recommended for Impulse Testing of Transformers

Circuit Voltage Class, Kv	Tentative Standard Coordination Gap, In.	Test Gaps, In.
2.3– 4.3 Y	2*	2 1/4
4.6– 8.67 Y	3*	3 3/4
6.9–13.8 or 15 Y or Δ	4 1/4	4 3/4
23	6 1/4	7
34.5	9 1/4	10 1/4
46	12 1/4	13 1/2
69	18 3/4	20 1/2
92	25	27 1/2
115	31 1/2	34 3/4
138	38 1/4	42
161	44 1/2	49
196	54 1/2	60
230	64	70 1/2

* Recommended by the transformer subcommittee on Nov. 18, 1932.

Communication Systems of American Railroads

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Typical communication requirements of a large American steam railroad system are outlined briefly in this article. Large railroad systems are complex organizations requiring extensive communication services to handle their special operating problems and to enable them to reach and serve the public adequately. Brief descriptions of the major requirements for circuits, switchboards, radio, carrier, plant, and apparatus are given.

A MODERN railroad system is vast and complex, having tens of thousands of employees and thousands of miles of far flung lines spanning half or more of our continent. To function efficiently such a large enterprise must be highly organized with a resulting division of labor into various departments that are more or less similar on all roads. There are many contacts between the railroad and the public it serves as well as between departments, necessitating comprehensive and continuous communication service.

Dispatching Circuit

At each division headquarters is located a train dispatcher, who directs the movement of trains over the territory under his control. To do this, he requires dispatching circuits either telephone or telegraph or both. These circuits are connected into each station in his territory. If a circuit is operated by telegraph, calling of the stations is by Morse code. If the circuit is operated by telephone, the dispatcher calls each station as desired by sending out coded impulses which operate as elector. The selector causes a bell to ring and sends a tone back to the dispatcher indicating that the bell has rung. Each station is provided with a high impedance local battery telephone set designed especially for this service. All stations may listen in without rendering the circuit inoperative. As the dispatcher is provided with a loud speaker that is always connected to the dispatching circuit a station operator simply connects his telephone to the circuit and proceeds to talk. Dispatching circuits vary in length from 15-mile terminal circuits to about 600 or 700 miles, depending upon the density of traffic; they probably average 200 miles. The number of stations connected thereto also varies widely from perhaps 15 to more than 100 miles, with an average between 40 and 50 miles.

Dispatching circuits are the most important on the railroad. The use of the telephone is considered preferable to the telegraph and each year sees an increase in the former at the expense of the latter.

Essentially full text of "Communication Requirements of Railroads" (No. 33-6) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23-27, 1933.

At the present time, nearly all main line and a majority of all mileage is dispatched by telephone. The circuits are usually composed of No. 9 AWG copper, although in some cases where territories are long or weather conditions severe, No. 6 AWG copper is used. These circuits are normally designed with a transmission equivalent of not over 20 db with a maximum of 25 db to the dispatcher. Often the dispatcher is located at some point other than the terminal, in which case the over-all equivalent may be as much as 30 db.

Block and Siding Communication

To increase safety of operation the block system was designed. The track is divided in sections called blocks averaging 8 to 10 miles long. In one system but one train may be in any one block at a given time; a modification permits a freight train to follow another freight train into a block provided it is first warned by signal or special instructions that the block is occupied.

The operators at each end of a block control the movement in and out of the block, and obtain information from each other as to whether the block is clear or not before permitting a train to enter. The necessary communication is provided by telegraph and telephone circuits, usually the latter. When telephone circuits are provided they may be simplexed to furnish a way station telegraph circuit. As block circuits are usually short, transmission considerations normally do not govern the choice of wire, which may be either No. 8 BWG iron or No. 9 AWG copper, depending upon which is considered the more economical.

When a train takes a siding it must be reported in the clear and permission must be obtained from the block operator before leaving the siding. Separate telephone circuits may be provided to the siding, or use may be made of the block or dispatching circuits. The instrument is housed in a booth or in a small box mounted on a pole.

Telegraph Way Circuits and Telephone Message Circuits

Where dispatching is by telegraph a second telegraph circuit, cut into the same stations as the dispatching circuit and often into additional stations, is required for handling general divisional business, and as an auxiliary circuit for the dispatcher.

Where dispatching is by telephone, either a telegraph way wire or a telephone message circuit should be provided. The message circuit is practically a duplicate of the dispatcher's circuit, but it usually has drops to freight houses, depots, and other places not connected to the dispatcher's circuit. Generally, it is terminated in a private branch exchange and the latter does the ringing. In case of failure of the dispatching circuit, the message circuit is used to make the former circuit good. The way telegraph or message circuits are required for the transaction of the local business of the division, such as car distribution, reservations, routings, rates and many other matters.

Long Distance Telephone Service

Various divisions are grouped under an operating head known as a general manager or general superintendent. Where the divisions under control radiate from the operating headquarters, long distance telephone service connecting these division offices with general headquarters is obtained by the use of a phantom circuit on the dispatching and message circuits. Otherwise, additional circuits are constructed or telephone repeaters provided for existing derived circuits. Service from the executive general headquarters to general operating and traffic officers is provided by means of trunk lines between strategic telephone switching points.

Telephone repeaters and entrance cable loading may be necessary to give satisfactory over-all transmission. As terminal losses on calls to local points, city ticket offices, etc., will usually equal or exceed 5 db, the trunk line equivalent between any 2 points should not exceed 20 db.

Private Branch Exchanges

At a large terminal or general headquarters there may be hundreds of commercial telephones serving various railroad offices. The need for convenient and economical distribution of calls for such offices with a minimum of inconvenience to the public has been met by the installation of private branch exchange switchboards. These switchboards are manned by trained operators employed by the railroad, who are familiar with the practices of the various departments and are able properly to distribute the calls to the persons desired. The local calls from one department to another of course are routed through this board.

The private branch exchange also is used to connect the railroad's long distance telephone lines with the local terminals. Switchboards may be either owned or rented from the commercial companies. They may be manual or semi-automatic as required.

In some cases it is preferable to install more than one private branch exchange to take care of certain types of specialized traffic. Generally, the larger city ticket offices and freight terminals are provided with exchanges of their own and separately listed in the directory. Outlying yards are often provided with separate boards. Executive offices desiring so-called secretarial service may require separate boards connected usually to a main private branch exchange.

Pullman Reservation and Information Bureaus

These 2 services require special communication arrangements. In the Pullman reservation bureau a diagram table is provided. It is usually double sided with a rack in the center containing the Pullman diagram cards grouped by trains. At the table are seated the diagram clerks from possibly 4 to as many as 40. Each clerk has a telephone and by means of keys can connect it to any one of a number of lines appearing in the table. Associated

with the table is an automatic telephone exchange and from the latter extend lines to the ticket sellers in the depot, city ticket offices, and other places where tickets are sold. The ticket seller desiring space dials the particular section in which he knows the diagrams for the train in question are located. Signal lamps will light in front of several clerks facing these particular diagrams and a clerk that is not busy answers and gives the desired space.

In addition to the above unit another somewhat similar unit is provided known as the public reservation. It is provided with direct trunks from the telephone company's central office and listed separately in the directory. Incoming calls may be received at a switchboard or the lines multipled through the table with lamp signals in front of all or groups of operators. At this unit are made advance Pullman reservations on direct request of the public. The clerks obtain the space by dialing the diagram table or going to it and securing the space directly from the cards.

The information bureau is provided with trunks from the city exchange and listed under a separate number in the directory. Incoming calls are distributed in the same way as for the public reservation table.

Centralized Reconsigning and Tracing Bureaus

Car tracing has increased greatly in recent years and the increased movement of perishable freight has resulted in a great increase in reconsignments and diversions. Modern trend is toward a centralization of tracing and reconsigning activities either for the system as a whole or for regions embracing about $^1/_4$ the system mileage. The movement of cars in through freight trains is telegraphed or telephoned to the trace bureau where cars are booked under a number system so that they can be located readily. All requests for tracing or diversions are directed to the bureau which can from its records handle the request with a minimum of delay. Regional bureaus can usually use existing communication facilities. In a central system, however, special telegraph circuits equipped with printers will usually be provided.

Morse Telegraph Circuits

A network of through telegraph circuits along the same plan as that of the long distance telephone circuits is required. A great variety of messages, daily situation reports, reservations, car tracers, diversions, home routes, and special equipment movements are sent over these telegraph circuits. The number of such messages on a large system will average from 12,000,000 to 36,000,000 or more per year.

The circuits are usually derived as simplexes and composites on the telephone circuits, but may when necessary be strung as single wires. With hand sending, circuits are usually operated duplex, permitting 2 messages to be sent simultaneously, one in each direction. When traffic is heavy, printing telegraph machines operated simplex, duplex, or multiplex are employed. When operated multiplex, as many as 4 messages can be sent in each direction at a time. In the longer circuits telegraph repeaters appropriate to the type of circuit are required at intervals varying with the weather conditions and resistance of the wire, from 150 to 300 miles.

In the larger telegraph offices belt conveyors along the operating tables for the collection of incoming messages are desirable. They speed up the movement of messages and usually effect savings in messenger expense. When these telegraph offices are in large office buildings, pneumatic tube delivery and pick up service is desirable. Tube systems also are very efficient in the distribution of building mail.

Local Printer and Announcing Circuits

Printers also find application in a number of local or short wire services. In the new type car retarder yards, the switching list is prepared on a printer and simultaneously transmitted to the switching towers so that switching need not wait until the entire list is finished. In addition a loud speaking telephone circuit is provided between the yard office hump and switch towers so that corrections, changes, and emergency information can be passed quickly.

Printers are often desirable at terminals for the transmission of orders concerning the arrangement, make up and changing of passenger equipment, and arrival of freight to downtown offices.

At large passenger stations the arrival of incoming trains is reported from outlying towers to the incoming bulletin board, station master, baggage room, telegraph office, taxi headquarters, mail room, etc. This is handled either by printer or telautograph. In connection with or in addition to this circuit, there is provided in some cases loud speaking or public address systems to announce the arrival and departure of trains.

Time Service

It is essential that accurate time be maintained on a railroad. Each day at noon eastern standard time, usually through arrangement with a commercial telegraph company, U.S. Naval Observatory time is sent over the telephone and telegraph networks of railroads to all stations. Formerly this was sent exclusively by telegraph, but at present both telephone and telegraph are used. Standard clocks are compared with the time signals and the variation is posted at the clock. When clocks vary more than 10 sec, they are set and regulated. Trainmen compare their watches with these clocks before starting on their tours of duty.

Accuracy and efficiency in dispatcher's and telegraph offices, telephone exchanges, and Pullman reservation and information bureaus are promoted when the room noise is lowered by acoustic treatment of the ceilings. Material having a coefficient of absorption of 0.7 usually will be satisfactory.

While there are a number of places where radio might be used advantageously in railroad service its use to date has been somewhat limited. In car retarder yard operation there is need for radio communication from the hump to the pusher locomotive in order to direct movements, especially in foggy or stormy weather. On long freight trains there is need for communication from the caboose to the engine; this is especially true in bad weather when signals could be passed by radio when otherwise impracticable. Some railroads have fleets of boats in tug and ferry service. In dispatching these boats there often is need to communicate with the boat after it has left the pier. This communication can be given readily by radio.

A number of railroads have installed, on their better trains, radio receiving sets for the entertainment of their passengers. Commercial radio telephone communication to passengers on moving trains has received some attention but is felt to be essentially a matter for consideration by the commercial companies.

The use of carrier telegraph or telephone systems largely depends upon cost considerations, i. e., whether additional circuits when needed can be obtained more cheaply by means of carrier or by stringing additional wire.

Plant Requirements

In the design of their communication pole lines, the railroads feel that they require a stronger pole line than usually is provided in commercial practice. This feeling is based upon the fact that alternate routes rarely are available to the railroad in case of prostration and the fact that a pole line failure disrupts the signal system, the wires of which are ordinarily carried on the communication pole line. The telephone and telegraph section of the American Railway Association recommends a minimum factor of safety of 2 for railroad pole lines.

Conclusion

From the foregoing it may be noted that the communication requirements of a railroad are extensive and exacting. In order to construct, maintain, and operate a communication plant efficiently a separate communication department is required provided with necessary technical engineers, construction men, wire chiefs, traffic men, etc.

The communication departments of the railways of the United States, Canada, and Mexico are organized under the American Railway Association into a telegraph and telephone section. This body, through its committees, prepares and promulgates standards for construction, maintenance, and operation. By its work great strides have been made in standardization of railroad practices with ensuing economy. The ideal to which the railroad communication service should strive is uninterrupted telephone or telegraph service between any 2 points on its system.

High Frequency for Arc Welding

Extensive tests have demonstrated important advantages favoring the use of high frequency current for electric arc welding and have led to the development of a 900-cycle double induction generator of attractive characteristics and capable of supplying several different arcs at once. Some test results and a description of the high frequency generator are given.

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EXPERIMENTS with induction generators operating at frequencies ranging from 500 to 9,000 cycles per second, have shown that currents of such relatively high frequencies have important advantages for use in metal arc welding and for other arc applications of heat. Experience with the inductor machines has shown them to have inherent characteristics that make them suitable for supplying current to electric arcs, and to give them both construction and operating advantages over d-c welding generators.

The generator as now commercially developed is of the double core type (see Fig. 1) designed to operate at 3,600 rpm to produce welding currents at a frequency of 900 cycles per second. The machine has the simplicity and the ruggedness of a squirrel cage motor, although the length of the air gap is almost twice that usually employed in an induction motor. The rotor teeth or poles are laminated, and the direction of rotation, of course, is optional. The relatively high speed enables direct connection to gasoline engines of similar speeds, resulting in portable sets, compact and light in weight.

The generator is self-excited, as indicated in Fig. 2, through a bridge connected full-wave rectifier. This generator circuit occupies 3 of the 60 stator teeth; the d-c field circuit is a single coil. The high reactance of the field coil at 900 cycles aids the operation of the rectifier and permits the use of the smallest number of units in series for the voltage needed. The higher frequency also lends itself to the use of condensers in connection with the excitation, in both the fields and load circuits. However, the results given in this article were obtained without condensers and with the field operated well below the

Full text of a paper (No. 33-33) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

saturation point. From the standpoint of arc welding still higher frequencies appear to have advantages, but a compromise was made at 900 cycles per second, partly to avoid the losses in core and rectifier at higher frequencies, and partly for structural reasons. Tests have shown the short circuit losses to check, or nearly equal, the total load copper losses plus the no load losses. Iron losses at higher frequencies also influenced the decision upon 900 cycles per second as the best operating frequency. As now designed, the generator efficiency is 80 per cent or

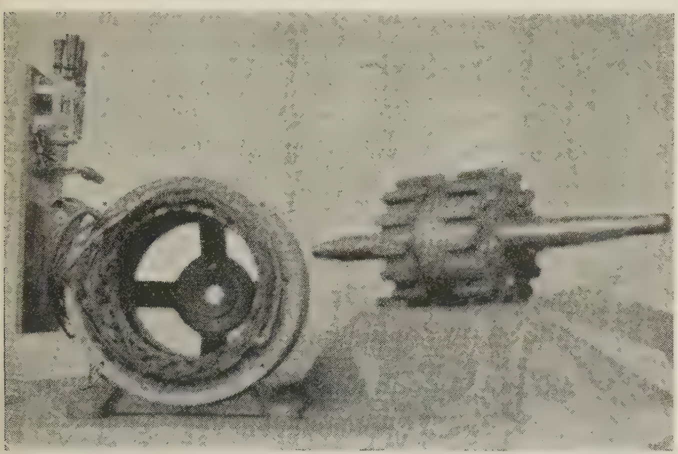


Fig. 1. A multiple-circuit 900-cycle 3,600-rpm, double-core single-field arc welding generator

higher for 200-amp and larger sizes. A $7^1/_2$-hp motor is used for the 200-amp size, 10-hp for the 300-amp size.

The multiplicity of welding circuits is noteworthy. By proper switching arrangement there may be as many operators as there are circuits (each circuit is independent; individual coils embrace only one pole, and there is but one coil per pole), or the circuits may be combined to give greater current capacity to fewer operators. The connection scheme shown in Fig. 2 would serve one operator with 2 arcs, or 2 operators each with 1 arc.

Volt-ampere curves for single circuits of this generator are shown in Fig. 3, where the dotted curves show values obtainable by field adjustment; however, as pointed out later, a field rheostat generally is unnecessary. As all the circuits have like characteristics and none is affected by the current in any other, the shape of the volt-ampere curve will be the same for all values of current obtained when several circuits are connected in multiple. For example, one main circuit may give $27^1/_2$ amp short circuited, 26 amp at 25 volts, and 85 volts on open circuit; then if 8 main circuits are used in multiple the short circuit current will be $8 \times 27^1/_2 = 220$ amp, the load current 208 amp at 25 volts, and the open circuit voltage 85. This holds for any number of circuits.

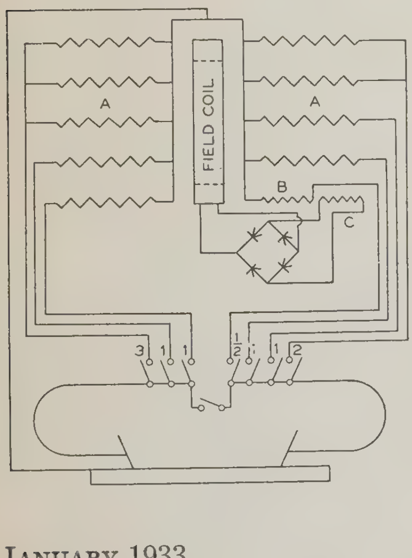


Fig. 2. Schematic diagram of the windings of the generator shown in Fig. 1

The 2 stator windings are divided into 10 welding circuits (A and B) and 1 field self-excitation circuit (C) involving a full-wave rectifier. Circuits may be switched according to number of circuits and welding current required

The half circuit, it may be explained, uses half as many poles as a main circuit and has twice the number of turns per pole; its characteristics are exactly proportional to those of a main circuit. It is used to provide a smaller step in adjusting welding current to the value desired for any given work. The generator is flexible in this respect. It may be seen that, by simple changes in the switching, several circuits can be used in series for higher open circuit voltages, or separate combinations of circuits can

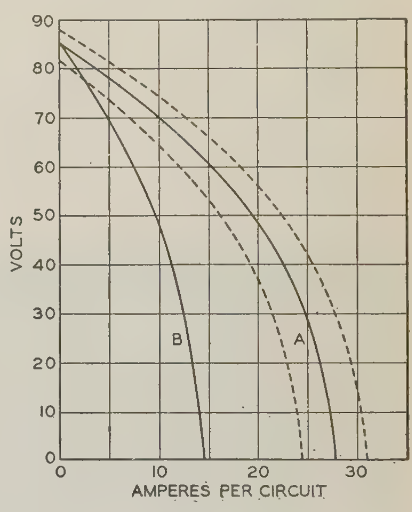


Fig. 3. Characteristics of 200-amp 900-cycle arc welding generator: (A) full circuit, (B) half circuit

have different voltages if not used in multiple. The characteristics of all such circuits will be similar and the short circuit ampere turns per pole for all will be the same for any given field strength.

These characteristics are entirely inherent in the generator; no external reactance or resistance is used. A set without field rheostat, even without instruments, is entirely practical from an operating standpoint. The switches afford all the control necessary and, being plainly marked either in amperes or units, indicate almost exactly the value of the current available for a certain setting.

In connection with the voltage regulation and the interrelation of circuits it is worth while to note that, although the statement that all circuits are independent of each other is true for all practical purposes, there is a small compounding effect. If, say, all but one of these circuits are shorted, the voltage on the open circuit will have a permanent rise of about 2 per cent with a 2 per cent drop in speed when the generator is self-excited; the field ammeter

will show a corresponding permanent increase in field current. When the generator is separately excited, as it may be from any constant potential d-c source, the field ammeter will show a small upward kick of about the same magnitude as the permanent rise when self-excited, not more than 5 per cent of the maximum throw of the needle. This slight compounding effect is the only evidence of any interrelation of the various circuits. When the machine is self-excited, the field current at open and short circuit is as shown in Fig. 4.

Fig. 5 shows that there are no surges of more than 10 per cent above normal in either voltage or current when short circuits were made and broken by wiping the welder's rod-holder quickly across the edge of the grounding base. It may be seen that the voltage and current curves show practically normal conditions immediately after the short circuit is broken or made.

Fig. 6 shows the voltage and current conditions while welding with a current of about 180 amp. These curves were taken with the same setting of the oscillograph as those in Fig. 5, and the same circuits of the generator were used for welding as were shorted in Fig. 5. The voltage curves of Figs. 5 and 6 were on a scale of 10 volts per mm. The open circuit voltage (Fig. 5 upper curve) has a value of approximately 100 volts maximum and the welding voltage (Fig. 6 upper curve) has a value of 43 volts maximum. These would be respectively, 71 and 30 effective, assuming sine waves.

In Fig. 6 is shown a short circuit of the arc that lasted for $2^1/_2$ cycles or about 1/360 sec, corresponding in time to $^1/_6$ cycle of 60-cycle current. The current curve shows a slight increase during the short circuit and a noticeable change of shape, the front of the current wave during steady arc conditions being peaked, but during the short circuit the 5 crests have their peak at the tail of the wave. By the flattened crests of the current waves the short circuit is predicted a few cycles ahead of its actual occurrence. The zero points of the waves show no shift.

The machine described makes a practical welding generator, with which metal arcs are easy to strike and hold, and good penetration is obtained. It is particularly good where the new heavy coated rods are used and in other work where reversed polarity of direct current is recommended. With a carbon torch this high frequency current also is useful. The arc projects so well away from the carbons that it is almost as handy to apply to the work as is a gas flame. In the case of the carbon arcs the no load voltage used is the same as for metal arcs. The carbon arcs operate at from 45 to 50 volts, with correspondingly lower current per circuit. It should be noted that this generator is operated at low open circuit voltage; comparable to d-c machines in this respect. Metal arcs are easy to strike and hold at from 65 to 70 volts. Arcs of smallest current values can be held successfully with open circuit voltages below 100.

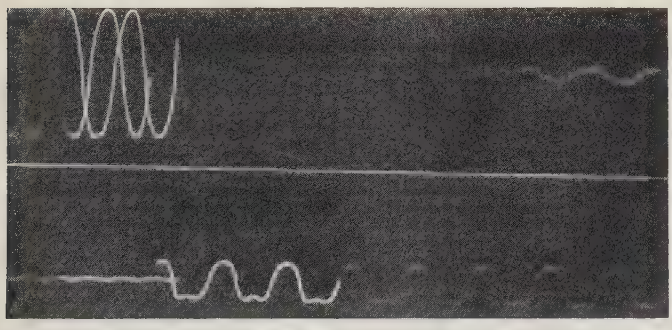


Fig. 4. Line voltage and field current of 900-cycle welding generator self-excited through rectifier; (left) open circuit; (right) short circuit (partially retouched)

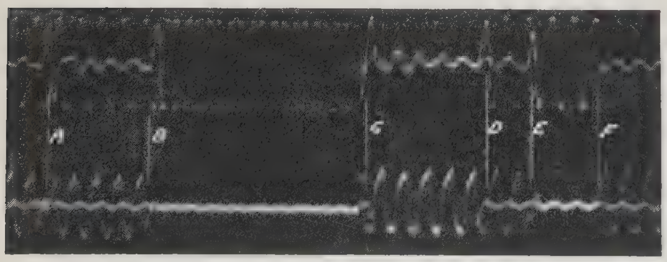


Fig. 5. Voltage (upper) and current (lower) characteristics of 900-cycle welding generator arising from make and break of short circuits

Momentary breaks at A and C; longer breaks at B, D, and E; make (circuit closed) at F

Fig. 6. Relations of arc voltage (upper) and current (lower) for 900-cycle 200-amp arc welding generator

Note the effects of short circuiting the arc (toward the right)

Among the features of this high frequency generator that command attention are:

1. Multiple circuits for more than one operator; simple adjustment of circuits.
2. No transients that affect the welding operation.
3. Low open circuit voltage.
4. Inherent regulation, no external reactance or resistance required.
5. High efficiency.
6. Self-excitation, or optional separate excitation from any d-c source.
7. Weight and cost low; less than $^1/_2$ the usual d-c machine; comparable to 60-cycle transformer equipments.
8. Three-phase loading of power lines as compared to single phase 60-cycle transformer sets.
9. Rugged construction of rotor; no windings; no commutator; no brush wear.
10. Optional direction of rotation.

Recommendations for Impulse Voltage Testing

Much of the data on impulse voltage testing of insulators and insulation which has been given out in the past has been obtained on a basis that renders it of little value for purposes of comparison and coordination. To clarify this situation the lightning and insulator subcommittee of the A.I.E.E. power transmission and distribution committee has conducted a study, the results of which are reported in this article. In this report the committee: outlines the present status of impulse voltage characteristic data for insulation; recommends a set of preferred test waves for laboratory use, discussing the use of these waves and test procedure with a view to obtaining comparable and coordinated characteristics of insulation; points out some of the limitations in securing impulse voltage characteristic data, and in the effective use of this data; and indicates the necessity for obtaining impulse data on a logical, accurate, and common basis, pointing out the benefits to be derived therefrom.

IMPULSE flashover data on insulators, which some 10 years or so ago could be secured in only 1 or 2 laboratories, today are obtainable in some 6 or 8 laboratories in this country. In addition at least 2 electric utilities now own and operate their own lightning generators. With this increase in the number of lightning laboratories, it was found that the data obtained and given out were not comparable, apparently because of the different types of lightning generators and circuits employed and the varying test conditions and setups, and particularly because of the different shapes of the impulse waves employed. These varying data were interesting so far as they showed that the impulse voltage characteristics of insulators were different from the 60-cycle voltage characteristics; however, the major possible benefit that might have been obtained from such data was vitiated because the data could not be applied directly in any design or application work, since no means of checking or determining their accuracy and reliability were available. Practically no 2 sets of data from 2 different laboratories were obtained on a common and comparable basis.

Intensive field research on natural lightning and the invention of the cathode ray oscillograph made possible 2 things:

1. Approximate determinations of the voltage wave shapes produced on transmission lines by natural lightning.
2. A determination in the laboratory of both the actual shape of the applied voltage wave and the point on the voltage wave where insulation breakdown occurs.

Both of these factors, wave shape and point of breakdown, or time, must be considered to obtain a complete and effective application of impulse test data.

It is now known that the polarity of the impulse wave, barometric pressure, and also the humidity of the air, affect the insulator impulse sparkover; it is known further that these factors affect different types of insulators to a different degree. While in some cases these factors have small influence on sparkover values, the effect may be great enough to prevent successful coordination or grading of insulation within practical and economical limitations, if the variations are not considered and properly allowed for.

Preferred Test Waves

It must be evident from the foregoing, that present data on impulse characteristics of insulators, protective gaps, etc., are available in such an incomplete form that they cannot readily be applied and used by those responsible for the design and successful operation of transmission and distribution systems and associated apparatus. It is the hope of the committee that the test waves and test procedure recommended here will be adopted generally, and will result in more rapid progress being made in the future in the accumulation of impulse data on a common, accurate, and comparable basis. It is hoped that this in turn will make possible the intelligent utilization of these impulse data in the art of generation, transmission, and distribution of electric energy so that both the power industry and the industries associated with it will benefit.

Full text of a report prepared by the lightning and insulator subcommittee of the A.I.E.E. power transmission and distribution committee, to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

Lightning and insulator subcommittee: Philip Sporn, *chairman;* W. W. Lewis, J. J. Torok, J. T. Lusignan, K. A. Hawley, H. H. Spencer, I. W. Gross, H. L. Melvin.

In order that the lightning flashover and puncture strengths of insulating members may be determined properly, the following are required:

1. Impulse test waves of definite and known shape.

2. The use of a sufficient number of wave shapes to allow lightning conditions in the field to be simulated at least approximately.

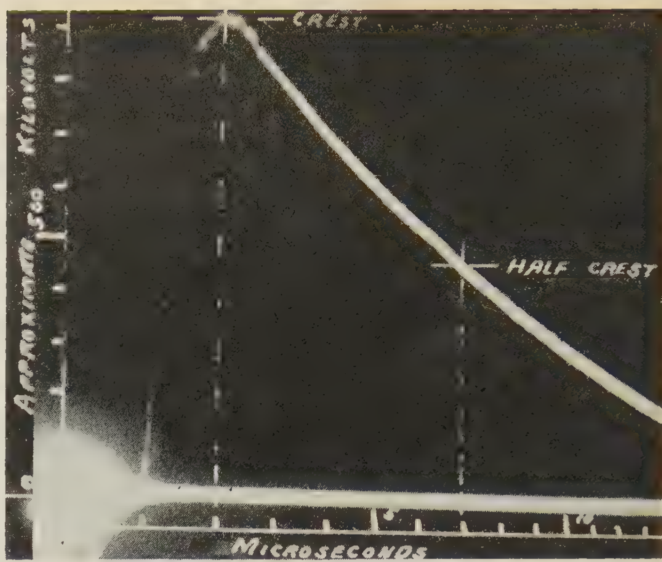
3. The use of wave shapes reproducible in laboratories within reasonable limits.

This committee recommends, therefore, that as far as possible, the impulse strengths of insulating members be determined from tests made with the following 3 wave shapes:

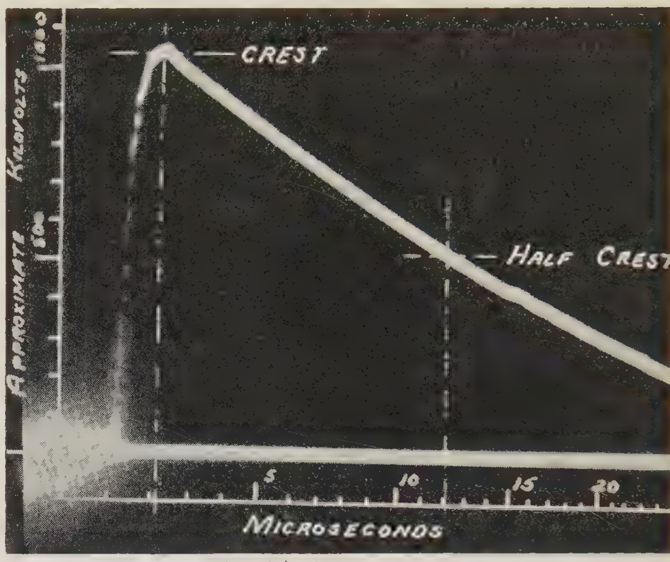
1x5 μsec   1x10 μsec $1^1/_2$x40 μsec

The first number in each designation indicates the length of the wave front in microseconds measured from zero voltage to the crest of the wave; the second number is the designated length in microseconds measured from zero voltage to that point on the wave tail at which the voltage is equal to *half* crest voltage. The reasons for designating that both the fronts and lengths be measured from zero voltage are: (1) the usual equations for impulse circuits determine time from the zero point; and (2) so that a common basis of reference may be established. The 1x5-μsec wave is recommended to replace the $^1/_2$ x 5-μsec wave recommended in the 1931–32 report of this committee because of difficulties encountered in securing the $^1/_2$ x 5-μsec wave in all laboratories.

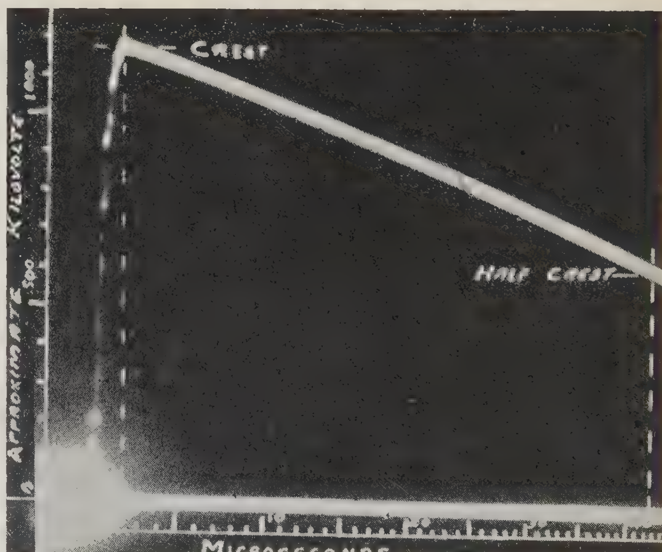
Field records have shown lightning waves to have fronts and lengths varying over an extremely wide range; it is believed, however, that the 3 recommended wave shapes cover a range sufficiently broad to meet, as well as is practicable in the laboratory, the requirements for determining insulation breakdown characteristics for natural lightning. The committee does not recommend that every laboratory impulse test be conducted with all 3 waves, but that when test waves are being selected, preference be given to one or more of these 3 so that the results can be compared and used on a common basis. In choosing these 3 waves, consideration was given as to whether or not they could be produced satisfactorily and consistently in the various laboratories. Wave fronts shorter than one microsecond have been used in the past, but it was felt that one microsecond should be the established lower limit. The reason for this is that while satisfactory wave fronts of a fraction of a microsecond can be produced at the lower voltages, it is practically impossible to secure them at the upper voltage limits of some of the present-day lightning generators. The ability to impose a potential of several millions of volts upon a test piece and its lead from the lightning generator within a fraction of a microsecond without excessive and indiscernible oscillations can be questioned. The insertion of series resistance in the test circuit to check the oscillations results in lengthening the wave front to the order of a microsecond, and sometimes even longer. Because of the decreased damping effect of the high shunt resistance required for the longer waves greater series resistance is necessary to prevent



1,000-kv 1 x 5-μsec wave



1,050-kv 1 x 10-μsec wave



1,200-kv $1^1/_2$ x 40-μsec wave

Fig. 1. Oscillograms of the 3 recommended impulse voltage waves as obtained in a typical lightning laboratory. Similar waves have been obtained in other recognized laboratories

oscillations on the front and crest of the wave. It is for these reasons that the $1^1/_2$-μsec front was chosen for the 40-μsec wave.

The wisdom of suppressing wave front oscillations in the manner indicated might be questioned by some, because in some cases lightning surges themselves may lack the proper circuit constants to eliminate oscillations on their fronts. In the laboratory, however, while it is essential to simulate lightning wave shapes as closely as possible, it is equally important that definite test waves be adopted which can be reproduced, measured, and recorded with reasonable accuracy. Not only are impulse waves with imposed oscillations of an appreciable magnitude difficult to duplicate consistently even on the same impulse generator, but also sphere gap measurements and oscillographic reproductions of such waves taken on the low voltage taps of potentiometers usually involve serious inaccuracies.

In recommending the 3 preferred test waves it has been necessary to compromise between the steepest and longest-tailed lightning waves so far observed on transmission lines, and the waves that can be obtained practically on insulation in a laboratory. That the recommended waves can be obtained in the laboratory is shown by actual oscillograms of impulse waves reproduced in Fig. 1. Similar waves have been obtained in other recognized laboratories. In Figs. 2, 3, and 4 are shown, in full lines, the 3 recommended test waves calculated from the circuit constants of the lightning generator. The dotted lines show the same 3 waves obtained by joining with straight lines the points actually specified in the definition of the waves.

Impulse wave shapes proposed or recommended by other A.I.E.E. committees also have been considered in an attempt to coordinate the several test waves in use. The transformer subcommittee of the electrical machinery committee have selected tentatively a $1^1/_2$x40-μsec wave for impulse tests to be applied to transformers. (See progress report on "Impulse Testing of Commercial Transformers," by Vogel and Montsinger, p. 9–11 of this issue.) Impulse waves recommended for lightning arrester testing by the lightning arrester subcommittee are defined both by rate of rise of the front and also by their ability to produce current through the arrester after the arrester comes into action. Such impulse waves cannot be used to give the desired information in insulator testing because: first, the voltage characteristics of the tail of the wave are not defined (tail of wave sparkover is an important factor in insulator testing); and second, it is impractical to obtain in the laboratory a constant rate of voltage rise, as the crest voltage of the test wave is altered successively in testing various types and sizes of insulators.

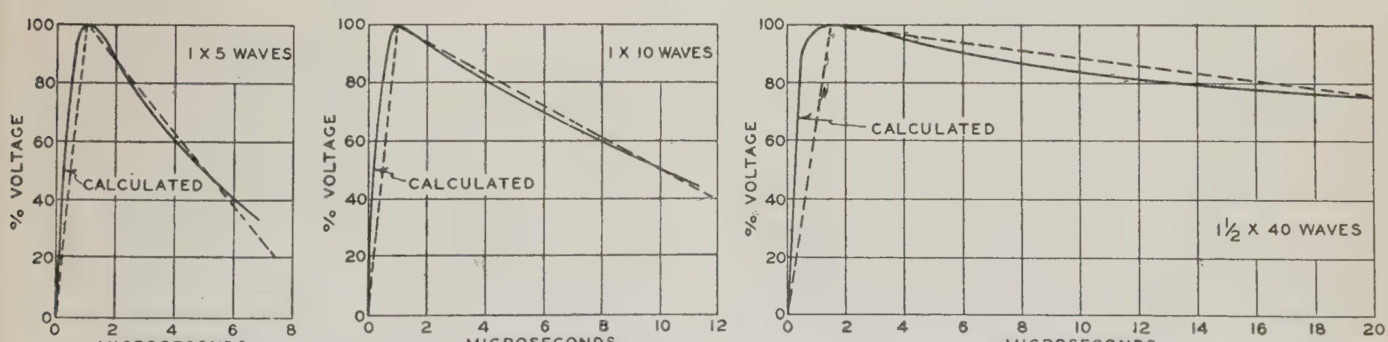
It is evident from the foregoing that the 3 preferred test waves recommended have been coordinated so far as is possible and practical with:

1. Natural lightning effects on transmission systems.
2. Reproducibility of these test waves in the laboratory.
3. Test waves proposed for impulse testing by other A.I.E.E. committees.

Technique and Precautions in Impulse Testing

Although the 3 wave shapes recommended are defined simply by front and tail characteristics, some difficulties may be met in producing them in the laboratory and in applying them to test work, if considerable care and precautions are not taken. The subject of impulse testing technique was discussed in 2 papers in 1932: "Characteristics of Surge Generators for Transformer Testing," by Bellaschi, A.I.E.E. paper No. 32–87 and "Impulse Testing Technique," by Foust, Kuehni, and Rohats, *G.E. Review*, v. 35, p. 358, 1932. Two additional papers are being presented at the 1933 A.I.E.E winter convention: "Laboratory Measurement of Impulse Voltages," by Dowell and Foust, A.I.E.E paper No. 33–49; and "Measurement of High Surge Voltages," by Bellaschi, A.I.E.E. paper No. 33–48. The lightning and insulator subcommittee commends the full and frank presentation of such discussions.

It is recognized that conditions under which the various laboratories must work are not at all identical, and that improvements constantly are being made in testing apparatus and methods. This committee, therefore, does not contemplate the standardization of test equipments, circuits, or methods. Rather, it is intended that the design and selection of testing equipment, the analysis of discharge-circuit current and voltage conditions, and the selection of test methods, be placed on such a basis as to leave no doubt that conditions of voltage application to the sample being tested are



Figs. 2, 3, and 4. The 3 recommended impulse voltage waves as calculated from the constants of the lightning generator. Dashed lines have been drawn through the points specified in the definition of the waves

known thoroughly and are demonstrable. For this purpose the following recommendations are made:

Testing Recommendations

1. Use only testing equipments and circuit arrangements that can be analyzed readily as regards the location and amounts of capacitance, inductance, resistance, and conductance constants present, all of which have an appreciable effect on the shape of the voltage wave applied to the test specimen.

2. Measure with reasonable accuracy such circuit constants as indicated in item 1.

3. Calculate voltage wave shape at the sample under test.

4. Take cathode ray oscillograms of wave shapes applied to the sample under test.

5. Compare the calculated voltage waves with the waves obtained in oscillograms.

6. Adopt such testing technique as is best suited to the testing equipment being used and the sample being tested.

7. Include with test results all details regarding each of the previous 6 items, such as will bear full evidence that testing conditions are thoroughly known and fully demonstrable.

8. Wherever possible, make impulse tests with both positive and negative applied voltage.

Measuring Sphere Gap

The measuring sphere gap, which commonly is used as the primary standard for determining the applied impulse voltage, should be selected in accordance with A.I.E.E. Standard No. 4. These standards apply to spheres up to 750 mm in diameter and to rms voltages up to 900 kv. At present there are no agreed-upon standards for spheres larger than 750 mm, although in several laboratories such spheres are in use and higher voltages are being measured by reference to calibration curves from different sources. It is recommended that the appropriate Institute committee take steps to extend the sphere gap calibrations.

Standard Temperature, Pressure, and Humidity

All test results obtained under prevailing temperatures, barometric pressure, and humidity conditions, should be corrected to the following standard conditions:

Temperature	77 deg F (25 deg C)
Barometric Pressure	29.9 in. (760 mm) of mercury
Humidity	That corresponding to a vapor pressure of 0.6085 in. (15.45 mm) of mercury (65% relative humidity at 77 deg F, and barometric pressure of 29.9 in.)

Sphere gap and sparkover voltages should be corrected to standard atmospheric conditions of temperature and pressure by the use of the air density correction factors given in A.I.E.E. Standard No. 4. It is assumed that there is no humidity correction for sphere gaps.

The test piece flashover voltage should be corrected to standard atmospheric conditions of temperature and pressure by the use of the relative air density correction factors given in A.I.E.E. Standard No. 4. Although air density correction factors would be somewhat more accurate, such factors have not been established for the various types of insulators and gaps.

Humidity correction, based on vapor pressure as discussed in A.I.E.E. Standard No. 41, must be determined from data accumulated on different types of insulators and gaps. Since correction factors for humidity are not now generally available for impulse voltages, it is recommended that a record always be made of the existing humidity, so that later the data may be corrected to a standard humidity condition.

Tolerances of Measurements

Since the practical application of impulse data on insulation involves, in most cases, the accuracy of the measurements, it is important that the possible and probable limits of this accuracy be known. It is recommended, therefore, that all impulse test data be accompanied by a statement of both the estimated possible and probable errors in magnitudes of voltage and time.

At present it is believed that discrepancies in the average sparkover voltage as obtained in different laboratories may be as great as 20 per cent on tests made with the short wave, and 5 per cent with the two longer waves; also in any one laboratory individual values vary ± 5 per cent from the average values. A better understanding and application of laboratory technique and test equipment promises, for the future, an appreciable reduction in these overall tolerances.

Practical Application of Impulse Data

The purpose of obtaining flashover characteristics of any insulation is, of course, to determine its electrical strength. In the past the electrical strength of insulation has been judged by its 60-cycle flashover voltage. Today it is recognized that lightning or impulse surges cause the greatest number of line flashovers; therefore, it is important to know the impulse flashover characteristic of the insulation.

One of the chief uses of information on the impulse flashover of insulators is for comparison purposes in the choice of insulation for proper coordination. Exact impulse characteristics of the insulation must be known if proper levels of insulation are to be established. To coordinate insulation properly throughout the entire range of impulses which might appear in practice, it is necessary to

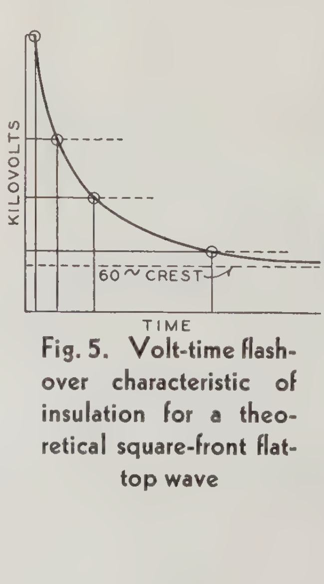


Fig. 5. Volt-time flashover characteristic of insulation for a theoretical square-front flat-top wave

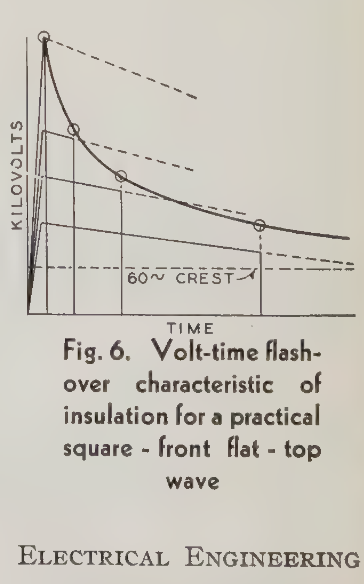


Fig. 6. Volt-time flashover characteristic of insulation for a practical square - front flat - top wave

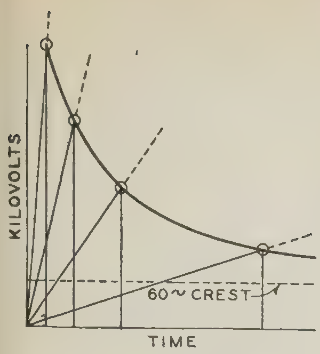


Fig. 7. Volt-time flashover characteristic of insulation with breakdown on front of wave

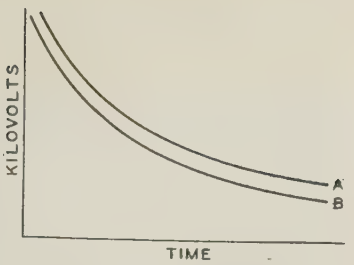


Fig. 8. Typical flashover characteristics of 2 coordinated insulating members

know more than the flashover value of the insulation at one point of one particular impulse wave.

At present, there are several ways of obtaining a nearly complete picture of the impulse characteristics of insulation. One of the most desirable of these is by determining what may be called the volt-time characteristic of the insulator. Volt-time characteristic curves may be obtained by applying an impulse potential across the insulator and determining the time required for flashover. Succeeding applications of voltage are made with different crest voltages, the time to flashover being determined for each application. The crest value of impressed voltage and its corresponding time to flashover then is plotted as shown in Fig. 5.

While theoretically this method of obtaining volt-time curves is highly desirable, it is impractical because in any laboratory where cost of equipment is a factor, it is impossible to obtain a square front flat top wave. However, the type of curve shown in Fig. 5, may be approximated by impulse waves, such as those shown in Figs. 6 and 7. In Fig. 6, a single wave shape is used at different amplitudes and all breakdowns are on the tail of the wave. In Fig. 7, all breakdowns are taken on uniformly rising wave fronts, the front being changed for each voltage application.

Another way of obtaining impulse characteristics of an insulator over wide ranges of time is to use waves of different shapes and determine by repeated application the minimum voltage which will just cause sparkover. This is called the minimum wave, 50-per cent sparkover method, that is, the minimum voltage which on being applied to the insulator, will cause sparkover half of the time. This method could well employ the 3 test waves recommended in this report, and does not require the continuous use of an oscillograph. The method becomes more accurate as the number of waves is increased.

It must be recognized that characteristic curves obtained by the 2 methods described are not comparable; that is, data obtained with the 50-per cent sparkover method will not have the same characteristics as data obtained with the methods illustrated in Figs. 6 and 7. At present, laboratory data available are insufficient to allow greater significance to be attached to one of these methods rather than to any other. Sufficient data should be obtained by the different methods to permit definite conclusions to be drawn as to the value of each method.

A survey of data already accumulated indicates that considerable information is available regarding the impulse flashover characteristics of various types and forms of insulation. However, a large part of the data has been obtained either by methods now obsolete or on a basis which would not be comparable with the methods outlined here, and particularly on a basis such that data obtained in different laboratories are not comparable. Only in the past year or so can data published by the more important laboratories be used for insulation coordination, and then only on that particular basis on which the data have been secured.

For the foregoing reasons it is essential that impulse data be obtained on some fixed basis for apparatus such as insulators, bushings, gaps, and other insulating members. This fixed basis may well take the form of a volt-time curve such as those illustrated in Figs. 6 and 7. However, it is clear that the obtaining of comparable data on these bases requires the use of a definite wave or group of waves.

Since both positive and negative waves are found on transmission lines, it is important in the laboratory to obtain impulse data for both polarities. Much of the earlier impulse data have been obtained without particular regard to polarity; consequently, the averaged values may lie between the positive and negative flashover values of that insulation. More recently testing has been done on a basis in which only one wave is used, either the positive or the negative. Since it was recognized that the positive impulse sparkover voltages were lower than the negative, it was decided to obtain the impulse information by using principally the positive wave. For complete and reliable coordination, however, it is necessary to have both positive and negative volt-time curves of all of the insulation involved.

For comparative purposes throughout a wide range of possible impulse voltages found in practice, the volt-time characteristics of an insulator give the most complete and therefore the most desirable information. By the use of these curves the relative behavior of 2 pieces of insulation subjected to impulse voltages can be predicted. For example, one form of insulator may have a characteristic curve as shown in Curve B of Fig. 8, and a bushing may have the Curve A characteristic; if the insulator and bushing are connected in parallel, the insulator will flash over, on the application of an impulse voltage, rather than the bushing. Predicting insulation breakdown on this basis is the ultimate aim of impulse testing. By this method the location of flashover of insulation can be controlled.

Coordination of insulation on the above basis may be expected to result in advantages as follows:

1. Protection of expensive and important apparatus against the effects of lightning should be more complete than at present, even where lightning arresters now are used.

2. Greater economy of system design should be possible without the danger of subjecting valuable apparatus to breakdown from lightning.

3. Lower maintenance costs on station apparatus subject to the effects of lightning may be expected, since it should be possible to prevent destructive impulse voltages from reaching that apparatus.

4. Electric service as a whole should be improved, since by insulation coordination, it should be possible to control the location of lightning flashover on the system so as to result in a minimum of damage and service interruption.

Conclusions

Important points brought out in this report and recommendations made by the lightning and insulator subcommittee may be summarized as follows:

1. Impulse voltage characteristic data on insulation which have been obtained in various laboratories up to the present time, have been on such widely different bases that the effective use of this data has been almost impossible.

2. The committee recommends 3 preferred impulse test waves, 1x5, 1x10, and $1^1/_2$x40 μsec, the use of which in all laboratories should result in comparable data being obtained on impulse characteristics of insulation.

3. That these recommended test waves actually can be produced in practice is demonstrated by the group of laboratory test waves, oscillograms of which are reproduced in this report.

4. To insure insulation actually being subjected in the laboratory to impulse voltages of known characteristics, a group of general recommendations for laboratory procedure have been made by the committee.

5. It is recommended that, wherever possible, oscillograms of the actual impulse wave or waves applied to insulation be obtained at the time of test.

6. For the intelligent application of impulse data in actual practice, tolerances or accuracies obtainable in laboratory measurements should be taken into account. Failure to do so may affect greatly the successful coordination of insulation on an electric system.

7. Complete information on the impulse characteristics of all insulating members of an electric system is necessary for proper coordination of insulation. This information is desirable in the form of volt-time curves, types of which are illustrated in this report.

It is hoped that the recommendations made in this report will offer a basis for more rapidly advancing the art of satisfactory insulation coordination on the impulse basis so that all possible economies in the design of electric systems and improvement in the service supplied by these systems may be actually realized.

Improved Power Supply Betters Street Railway Service

By
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This is a distinctly "different" type of discussion of a study of the economic and social results of a 4 years' use of automatic and supervisory control on the power supply system of the Cincinnati Street Railway. It is written from the viewpoint of an executive or an operating engineer, accurately reflects operating experience, and is designed to be of assistance to those who may be contemplating similar developments. It touches upon several extensive topics of which space prohibits development, but the recognition should be thought-provoking.—Editors.

AUTOMATIC stations with superimposed central supervisory control have been in service on the electric power supply system of the Cincinnati Street Railway since 1928. Experience of 4 years operation of this system are discussed from the viewpoint of the operating executive or the operating engineer who may be contemplating similar improvements. There are many questions of both economic and social significance facing such an operating executive. An endeavor is made to answer these questions by recounting and interpreting operating experience on the Cincinnati system. Only incidental attention is given to details of design, construction or installation.

The operator is presupposed to be an idealist endeavoring in a practical way to serve society as a whole. In considering the use of automatic and supervisory control, he has in mind the following questions:

1. What is the extent and nature of failures that may occur on a complete system of automatic and supervisory control?

2. What will be the effect of such a system on annual operating cost?

3. How much capital will be required?

4. To what extent will such a system improve service?

5. What will be the effect of such a system on society, particularly on the car-rider and the employee?

In order to discuss these questions relative to the automatic and supervisory control system at Cincinnati, it is necessary to review briefly the causes and conditions leading up to the installation of this

Full text of a paper to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933. Originally listed in the preliminary program under title "Operating Experience With Automatic and Supervisory Control."

system, and also to outline the functioning of the various equipment.

At the opening of the 20th century, the power required for electric traction, by the Cincinnati Street Railway was generated at 6 separate plants. The equipment at that time consisted of non-condensing reciprocating engines, belt-connected to 550-volt d-c generators, with a fuel consumption of 6 lb per kw hr. In 1911 the Pendleton generating plant was built on a site adjacent to the Ohio River. This plant consisted of 3 6,000-kw turbine generators which operated at high vacuum and produced a kw-hr from 3 lb of coal. This plant generated 25-cycle 6,600-volt 3-phase power which was distributed to 5 synchronous converter substations, 3 of which replaced old generating plants.

No further change was made in the power system until 1921 when a definite improvement of the service was made by purchasing power from the local power company. This power, which represented 50 per cent of the total requirements, was furnished at 7 locations, replacing all of the old d-c generating plants and creating 3 new distributing points, thus bringing the total number to 11. Three of the 60-cycle substations installed in 1921 were made fully automatic. It was chiefly on the basis of experience with these that the entire system was made automatic in 1928. Feeder equipments on these stations were the first to make use of current transformers on d-c circuits.

In 1927 the Columbia generating station was placed in operation by the local power company; it soon was producing a kw-hr from 0.9 lb of coal. During this year the railway company contracted with the power company (Union Gas and Electric Company) for all of its power requirements, this power to be metered on the high voltage side of the railway substation transformers.

At the time this contract was negotiated, approximately half of the railway power was generated by the Pendleton plant and was distributed through 5 substations, the most important of which housed also a 60-cycle converter. The least expensive scheme for complete 60-cycle operation would have been to replace the existing 25-cycle substation equipment with new 60-cycle apparatus. However, several circumstances were responsible for the broader policy that eventually was adopted giving greater consideration to the car-rider. Perhaps the most important of these circumstances was the fact that a complete reorganization of the railway company took place in November 1925. The Cincinnati Street Railway Company, after leasing its property for a period of 25 years, resumed operation under a new "service-at-cost" franchise. According to the terms of this franchise the railway company was obligated to rehabilitate the system and improve service.

Present System

In an effort to take full advantage of the possibilities of automatic control to improve service economically, the present system of power distribution makes use of an unusually large number of small substations. A total of 20 substations are in service comprising 3 2-unit stations of 3,000-kw total capacity each, feeding the congested area and 17 single unit stations, 10 of which are of 1,500 kw, 9 of 1,000 kw, 1 of 300 kw, and 1 of 200 kw.

Three-phase 60-cycle power is purchased from the local power company at 13.2 kv. The railway substations are served from the same high voltage lines that supply other industrial loads. These are underground in the downtown district and overhead in the outskirts of the city. The 2-unit stations are served by 2 lines from different sources; the single unit stations are fed from a single line which is usually a tap from a loop that can be sectionalized on either side of the substation connection.

The d-c buses of all of the substations are tied together through the feeder system. Of the 51 d-c feeders, 40 are of the multiple type, acting both as tie-lines and trolley feed, and 11 are stub feeders, all of which feed outlying areas. Twelve automatic outdoor sectionalizing breakers are used in connection with the multiple feeders to sectionalize further the distribution system. Thus although the system is sectionalized adequately, it is tied together to such an extent that failure of any substation affects only slightly the transportation service.

With the exception of the stub feeder breakers and control there is no single piece of substation equipment the failure of which will affect the transportation service materially. Except for economic considerations there is no reason why even the stub feeders should not be arranged in this manner.

The system outlined in the foregoing paragraphs could not be operated satisfactorily without constant supervision of all principle equipment and devices, for the reason that no one would know when a single failure had occurred. A transportation failure would have to take place to attract attention to substation trouble and as a rule this would be caused only by a double failure. Experience has shown that most double failures can be eliminated by taking care of every case of trouble promptly.

This constant supervision, which is necessary for satisfactory operation, is provided for on the Cincinnati system through the use of the synchronous selector type of supervisory control. The operation of every important piece of equipment and device on the system is supervised. Remote indicating meters, in the power dispatcher's office, show the load being carried by every converter on the system. Since the d-c bus voltage is a measure of the service being rendered by the substation system, remote recording voltmeters are located in the dispatcher's office to indicate and record the voltage on each substation bus.

Remote control has been provided so that the power dispatcher can start or stop any conversion unit on the system or open or close any feeder breaker. At 2-unit stations the dispatcher controls the high voltage service breakers and at other locations where it works out to advantage, he controls the sectionalizing of high voltage service lines. The automatic control of all units is arranged so that when shut down, they are disconnected automatically from the high voltage bus.

Remote control has been superimposed upon the automatic control in such a way as to leave with the power dispatcher the option of operating with automatic control or with remote control. At present the control normally rests with the automatic equipment at the substation, with the dispatcher assuming control when a feeder is ordered out to insure public d-c feeder involved. The trip point of the breaker, therefore, depends on the rate of rise and not on the magnitude of the current. This feature makes it possible to clear feeder faults that involve fault currents of smaller magnitude than the actual load current. The reclosing of a feeder breaker following a short-circuit is dependent on circuit conditions.

Table I—Total Annual Unit Outages on the Electrical System of the Cincinnati Street Railway Company

Source of Trouble	Substations	Units	1930 No. of Outages	1930 Total Hours	1930 Availability Per Cent	1931 No. of Outages	1931 Total Hours	1931 Availability Per Cent
Flashovers on stations not equipped with high speed breakers		2	16	9.1		24	23.2	
Flashovers on stations equipped with high speed breakers		21	1	1.0		1	2.8	
Other converter failures		23	23	1421.4		6	1595.5	
High speed breakers		21	8	29.2	99.22	11	44.0	99.05
Control		23	43	50.2		25	18.7	
Unknown		23	5	1.9		1	0.4	
Converter repairs		23	60	63.6		20	224.6	
Supervisory equipment	19		65	159.0	98.54	46	98.1	99.66
Supervisory cable	19		69	2276.1		55	545.9	
High voltage service	20	24*	49	16.2	99.992	86	10.0	99.995

* Incoming Lines

safety during a fire or as a result of wind-storm. The automatic control has been found to respond to emergencies quicker than is humanly possible, and therefore is preferred for normal operation.

Substation Equipment

All substation equipment including transformers and high voltage switching are indoors. Current and potential transformer, oil circuit breakers, disconnecting switches and potheads are completely inclosed in the high voltage structure. This structure is connected by 3-conductor cable to pothead type transformers, thus eliminating all exposed high voltage lines. All of the converters are compound wound, but are designed so that they can be operated as shunt machines by merely short-circuiting the series field. At present, only those converters feeding the congested sections of the city are operated as shunt machines. In other parts of the city fast schedules require the maintenance of voltage with increasing load at as high a point as is feasible.

High speed breakers have been placed in machine circuits and have eliminated flashovers entirely even though trolleys are tapped to feeders immediately adjacent to the substations. Two sections of load-shifting cast-iron resistance, shunted with breakers and having a current-carrying capacity equal to that of the converter, also have been placed in each machine circuit. Thermal protection for these grids has been eliminated since the thermal relay protecting the converter likewise protects the grids. In operation this resistance provides a sharply drooping bus voltage, equivalent to an accentuated shunt converter characteristic. However, they are switched into the circuit only when the load on the converter exceeds 175 per cent of full load rating.

Feeder breakers are of the latched-in type incorporating a magnetic blowout. The tripping impulse is derived from the secondary current of a current transformer whose primary consists of one leg of the After a breaker has opened, a time delay of about 15 sec is introduced in order to allow conditions to stabilize. The magnitude of the feeling-out current by-passed around the breaker then indicates the external circuit conditions, the breaker reclosing when this current reaches a predetermined value.

Supervisory Equipment

A complete system of supervisory control and remote metering has been superimposed on the full-automatic substations. Since the substations revert to full-automatic control upon failure of the supervisory system, failure of this system corresponds to a failure of supervision and in no way affects the transportation system.

Complete supervision is maintained by providing the dispatcher with continuous visible indications of the functioning of the apparatus at each substation as follows:

1. Condition of supervisory control equipment and cable.
2. Availability for service of each incoming high voltage line.
3. Position of each incoming high voltage line breaker.
4. Whether or not the station control batteries are being charged.
5. Whether the substation door is locked or unlocked.
6. Whether the converter is under supervisory or automatic control.
7. Whether the converter is running or stopped.
8. Position of load-shifting resistor contactors.
9. Sequence of starting for converters in 2-unit stations.
10. Whether each d-c feeder is under supervisory or automatic control.
11. Position of each d-c feeder breaker.
12. Load on each converter.
13. Voltage on each substation bus.

Furthermore, if in any substation any change takes place in the normal operation, or in the operation as set up by the supervisor, then the supervisor's attention is directed to it by audible annunciation,

and the specific location and change is indicated by lights.

Remote control has been provided so that the dispatcher may control apparatus in each substation as follows:

1. Open and close each breaker on the incoming high voltage lines at 2-unit substations.

2. Change the control of each converter to automatic or supervisory.

3. Start or stop each converter independent of automatic control.

4. Change the control of each d-c feeder breaker to automatic or supervisory.

5. Open or close each d-c feeder breaker independently of the automatic control.

System Performance

The entire system was completely installed and placed in operation by the latter part of 1928. During 1929 the d-c feeder system was revamped and many of the faults incident to the use of new untried equipment were eliminated permanently.

Several faults occurred during the first year of operation which, believe it or not, were the result of too much ventilation. In the design of the buildings a great deal of thought had been given to using the fan action of the converter to create a natural flow of air; exhaust ventilators were located so that the static and velocity air pressure would be cumulative. Inlet openings to the basement were made unusually large and gratings outside of the pedestal blocks supplied cool air to the suction areas of the machines.

This arrangement was quite effective and worked to advantage during the summer months. One winter day, however, the outside temperature rose sharply coincident with a warm rain. The result was astonishing: The inside of nearly every substation was drenched with water; switchboards, high voltage structure, ceiling, wall, and floors—everything was dripping wet. Insulation broke down at several stations on the control boards and in the high voltage structures. The remedy, however, was simple: During the winter months most of the ventilation was blocked and the losses of the transformers and converters were then adequate to keep the temperature within the stations at all times above that of the outside air; this effectively prevented condensation.

Annual unit outages for 1930 and 1931 are shown in Table I. Outages charged to other converter failures during 1930 were the result of commutator trouble on the new converters which now has been corrected permanently, as has similar trouble with the commutators of chargers for the station control and supervisory control batteries. During 1931, other converter failures included a 1495-hr outage of a converter on which the armature was destroyed because of insulation failure.

Outages charged to high speed breakers are debatable due because these breakers deliberately were removed from service during light load for recalibration. If real need for the machine had developed a jumper could have been installed. No outages of this nature have occurred during 1932.

Analysis of the control failures of 1931, shows that 37 per cent was caused by mechanical troubles, 22 per cent by poor contacts, 15 per cent by burned out resistors, 13 per cent by burned out coils, 11 per cent by blown fuses, and 2 per cent by open control wire. Analysis of the supervisory control failures, for 1931, shows that 32 per cent was caused by mechanical failures of interlocking devices and auxiliary relays, 27 per cent by faulty selector adjustment, 14 per cent by broken wires, 10 per cent by poor relay contacts, and 17 per cent by miscellaneous causes.

A great deal of trouble has been experienced with the supervisory control cable used to interconnect devices in the dispatcher's office. For some unknown reason this lead-covered rubber-insulated cable became literally rotten and disintegrated. This now has been replaced by cable of similar construction which so far has given perfect satisfaction. The total time that the supervisory equipment was out of service due to the replacement of cable together with outside cable failures or cable rerouting has been charged against supervisory cable.

Outages from failures of the high voltage service, although constituting a very small proportion of the total outages, nevertheless were responsible for practically all of the transportation failures. Apparently the stage has not yet been reached where power house failures are unknown or where all faults on the high voltage distribution system can be sectionalized perfectly.

Transportation Failures

In considering the record of equipment failures, most important is of course the extent to which they affected transportation service. Accordingly, the records of the transportation department were checked carefully for delays that could be attributed to the substations. In 1930 2 failures occurred, both due to flashovers of a small outlying substation, which caused the delay of cars operating on one route for a total of 20 min. This situation was recti-

Interior of the depot substation of the Cincinnati Street Railway Company

fied by installing additional cable in the tie-line connecting this station with the rest of the system.

There are no records of transportation failures reported by the transportation department during 1931 or 1932 that were attributable to substation equipment. It is true of course that practically every substation failure resulted in a decrease of trolley voltage but, with the exception of the cases mentioned, this drop in voltage was insufficient to be noticeable as a cause of running late.

One high voltage outage during 1930 caused delays to 15 routes for an average duration of 8.4 min. During 1931 3 high voltage outages caused an average delay of 9.0 min. to 17 routes.

Operating Costs

A significant phase of the project is the cost of supervision, maintenance, and operation of the system. Table II shows the results of operation for the past 3 years. Account numbers are those prescribed by the Interstate Commerce Commission.

Table II—Annual Cost of Operation and Maintenance

Account Number	Account	1929	1930	1931
45	Superintendence of power	$ 7,740	$ 7,740	$ 7,740
46	Buildings, fixtures, and grounds	2,400	2,000	1,880
48	Substation equipment (including maintenance of supervisory equipment and control cable)	22,660	20,750	21,890
57	Substation employees (dispatchers)	7,430	7,310	7,040
58	Supplies and expenses	4,220	3,160	3,160
	Total	$44,450	$40,960	$41,710

Note.—These total annual costs are for 19 substations and 22 converters during 1929 and 1930, and for 20 substations and 23 converters during 1931.

Capital Investment

Although this article is concerned primarily with operating experience, it was thought that executives and engineers would be interested in the amount and apportionment of the capital invested in different parts of the system. Table III therefore has been included.

Table III—Capital Investment

	Land	Buildings	Equipment	Total
19 substations and 22 conversion units of 29,300 kw total capacity	$106,800	$490,200	$1,085,400	$1,682,400
Supervisory control and control cable	4,000	12,000	164,000	180,000
Total	$110,800	$502,200	$1,249,400	$1,862,400
Per kw installed	$3.78	$17.15	$42.64	$63.53

The apparent high cost of substation buildings is due to several causes: first, they were designed to be pleasing from an architectural standpoint as well as servicible and adequate for operation; second, all of the 1,000-kw substation buildings are designed to accommodate 1,500-kw units and 6 buildings are designed to accommodate one additional unit.

Included in the amount charged against supervisory control and control cable is $64,000 for 43 miles of overhead lead covered paper insulated cable supported from the trolley poles.

Improved Service

Schedule speed is the factor which interests the public more than any other. In several outlying sections where the trolley voltage had been particularly poor, the increased schedule speeds resulting from improved voltage were quite apparent to the public. Using the year 1926 as a base, the average annual schedule speed for subsequent years varied as follows:

1927	0.6 per cent slower
1928	2.0 per cent faster
1929	4.6 per cent faster
1930	5.4 per cent faster
1931	6.2 per cent faster

During the years 1927 and 1928, in addition to the installation of new substations, 20 per cent of the rolling stock was replaced and 17 per cent of the track reconstructed. These factors, together with the constantly changing traffic make it impossible to determine definitely the proportion of the increased speed that should be credited to the new substation system. If, however, the 50,000,000 hours spent annually by the car-riding public in Cincinnati were reduced only 1 per cent by the new substation system, and this time were valued at 50 cents per hour, then the annual saving to the public would amount to $250,000. Another advantage accruing to the public from the new power system is the decided improvement in car lighting.

Operating Organization

To one closely associated with the organization that operates and maintains the Cincinnati system, it seems to function in a very simple way. The power dispatcher, the key man—one is on duty 24 hours a day every day in the year—is located in an office equipped with audible and visual signals that continuously and automatically check the operation of every important device. He knows the whereabouts of every man in the organization—their capabilities, experience, availability—and has at his fingertips a private telephone system to communicate with them. Although the means are available, he is seldom called upon to use remote control. His primary function is to spot failures and to get the most qualified available man on the job. He also keeps most of the records.

The power dispatcher's right-hand is the trouble-man, continuously on duty with him. When not out on trouble, he acts as inspector, and during the day when the maintenance men are available for trouble, he is engaged in all sorts of maintenance work varying from cutting lawns, trimming hedges, and painting buildings, to repairing automatic control or the supervisory cable. Together with the spare man, shop man, and janitor, the trouble man engages in a wide variety of work. The "spare" acts as relief dispatcher, maintenance, or trouble man. The shop man as a rule handles the extraordinary work, such

as the transfer or repair of supervisory cable or the changing or installation of new equipment. The janitor helps everyone and everyone helps him.

The actual routine and extraordinary maintenance of the system is handled by two maintenance crews of 3 men each on duty 8 hours a day 6 days a week. The entire system including the supervisory control board is divided into two parts with 10 substations comprising each part. One crew is in charge of the eastern division, the other of the western division. Routine maintenance consists of a thorough cleaning, inspection, and trial of all protective devices and feeder breakers once every 2 weeks. In addition, maintainers take care of the shrubbery and buildings and are subject to trouble call at any time during the day. The maintainers' working hours are arranged so that one crew is on duty during the morning peak, the other during the evening peak.

Although the superintendent of substations supervises all maintenance operations including the activities of the power dispatcher, the dispatcher has all authority necessary to get action from any man in the department in the event of equipment failures. With an organization like this there is little red tape.

Effect on the Public

Undoubtedly the most important social aspect of the development outlined in the preceding pages is the reaction of the car-riders to the project. The new substations were placed in service gradually and trolley voltage raised throughout the city, the car lighting was greatly improved and speeds definitely increased. During the first year of operation the improved service did elicit some favorable comment. In general, however, the public seemed to accept the improved service as a matter of course. As a matter of fact during the past 3 years the public relations department has received practically no comments that could be construed as being for or against the present system. This is discouraging, considering the time, effort, and money that has been expended to improve service. The net effect of such an improvement on the car-rider evidently has been to remove the power supply part of the system from his conciousness.

This does not mean that improved service does not influence behavior. Without a doubt speed is the dominating factor influencing the public's choice of transportation; but the car-rider is interested in relative speed and determines this by his watch. The effect of stops, motor design, power system, or traffic lights are elements that as a rule do not create separate reactions. Continuity of service is taken for granted; the public is not even aware that such a factor exists—until the cars stop running.

As is usually the case, the general public has reacted most favorably to those features of the new power system which from a strictly economic standpoint were least justified. For instance, a particular effort was made in connection with the housing of the various substations, to erect buildings and landscape the grounds so that the project would be a distinct credit to the community. The shrubbery always is kept in first class condition; in several locations this has had the effect of distinctly raising the tone of the adjoining property. At one location where an excess of property was available in the rear of the substation, an arrangement was made whereby a church organization was permitted to occupy the unused ground with tennis courts. The dispatcher's

Mitchell substation of the Cincinnati Street Railway Company

office, which houses the supervisory board, has been made as attractive as possible, and that is the feature more than any other that draws forth favorable comment from the non-technical visitor.

The Investor

In business ventures there is always the short run and the long run view. The first anticipates immediate maximum profits. The second looks toward stabilized long run profit and security of investment, the result of increased patronage attracted by good will and better services.

If a short run view had been taken of the project, it is possible that there would have been a narrow, short sighted effort to reduce capital expenditures to a minimum in an attempt to effect the greatest possible return on the investment. Where would the ax have fallen? Would there have been fewer distributing points, with resulting irregularity in trolley voltage and more opportunities for failure? Would cheaper buildings have been built, showing less consideration for the neighborhoods wherein the substations were located? Would the supervisory control have been installed? This is difficult ground. If the idea that Stuart Chase advances in "Men and Machines" is to be taken seriously—that technological tenuousness is one of the limiting factors of our machine age, and that this is due to our vast interconnected electrical systems, developing extremely vulnerable points, where failure may mean catastrophe—supervisory control would be considered essential to the public welfare. From experience

at Cincinnati it is difficult to see how a full automatic substation system could be operated successfully without supervisory control; yet it is possible that an organization dominated by a short sighted profit motive would take this chance.

Should bondholders take any particular interest in the physical property or objectives that their money is to be used for, or should they be concerned only with the security of their investment? It would seem that if the ultimate purpose of all of us is to advance the welfare and happiness of man, then the bondholders should concern themselves to some extent with the purposes to which their funds are to be put. Certainly "providing improved service for the public" not only rings truer than "increasing profits of stockholders," but in the long run is more likely to insure security of investment. For this reason adequate funds should be made available for projects that make for progress, even before all opportunities for increasing efficiency are taken care of.

The Employee

Probably no subject is more popular today among critics of our civilization than that revolving about the theme of the increasing monotony of labor due to the mechanization of industry and the displacement of workers by machines. Those engineers to whom progress is synonomous with efficiency, and even those who have a broader conception usually have admitted these charges and have pinned their faith on the hope that genuine social progress would result from the consequent shorter hours for labor, the development of new or better products and services, or the increased use of present products and services stimulated by lower prices.

If workers are being reduced to automatons, or finely specialized units with limited functions, the resulting gain in efficiency, shorter hours, or increased wages, may or may not be adequate compensation. In any case an adequate report on a project would be incomplete without considering these factors.

Engaged in operating and maintaining the power supply system of the Cincinnati Street Railway are 15 men. Not one of these men has work that by any stretch of the imagination can be considered routine or monotonous. Every day is different. Failures that occur are never exactly the same. The maintenance men working as they do in different parts of the city each day, necessarily are placed on their own resources and initiative; they do all manner of maintenance work, from adjusting relays to trimming lawns and painting buildings. The 3 dispatchers are the only men who remain in the same place, but even they rotate shifts every 2 weeks. The nature of the work keeps every man alert and there are improvements in the scheme of operation that are creditable to nearly every man on the system.

Since the system was placed in operation about 3 years ago no one has been hurt seriously, and only one man has been replaced. Hours have been shortened, but no men have been dismissed on account of the depression. An 8-hour day, however, is about the minimum for the necessary work because the substations and equipment are spread over an area of 100 square miles and a large portion of the time necessarily is spent going to and from them.

Unquestionably, the system at Cincinnati demanded a great deal of mental effort for its design, construction, and installation; and in service it still demands more mental effort, and manual skill to operate and maintain than did the old manual equipment. It is this very fact, however, that makes it interesting to the man. Happiness and satisfaction on the job is certainly contingent to a large extent on the full use of a person's faculties.

As to the other charge, that, technical improvements, showing a profitable return on the investment, result in retirement of workers, there can be no argument, for the major saving is always in operating costs, of which the greater portion is labor. Increasing efficiency combined with competition forces the retirement of both labor and capital without compensation. Where this condition is unforeseen and unprovided for, hardships naturally result.

Many progressive managements by suitable charges provide for the inevitable depreciation and obsolescence of capital. Labor could be assisted and encouraged to set aside, in a similar manner, insurance funds for carry over and retirement. If funds required to finance technical improvements were secured from these accumulated charges, which provide for the retirement of both capital and labor, then the due portion of the return on the investment would be used for carry over and for pensioning the

Supervisory control room for the Cincinnati Street Railway Company's entire power distribution system

incapacitated labor and a great deal of the injustice due to technical improvements would disappear.

The engineer as well as every other realist knows that a happy solution of the problem of controlling the results of efficiency is possible. In the hands of our business executives and political leaders lies the solution of this problem—the one most vital to the welfare and happiness of man.

Pipe Line Pumping and Automatic Control

Discovery within recent years of large oil-producing areas has greatly stimulated the development of the pipe line industry, making it an important customer of the electric utility and manufacturing companies. The application of electric motors and control equipment to pipe line pumping stations is described in this article. The fundamentals of pipe line pumping are emphasized for the benefit of electrical engineers not familiar with this industry.

By
JOHN FIES
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ELECTRIC motors and control equipment are being applied most successfully in pumping stations on pipe lines for transporting crude oil and petroleum products such as natural and refined gasoline. The high speed of the electric motor makes it suitable for use with the centrifugal pump, giving very satisfactory characteristics of pipe line flow. More satisfactory operation as well as a reduction in cost of pumping are being secured by the use of electric motors with automatic control.

Crude oil pipe lines may be classified as either gathering lines or trunk lines, while gasoline lines are usually trunk lines. Gathering lines are usually 4, 6, 8, and 10 in. steel pipe and are provided with pumps as needed. The pumping equipment on gathering lines in proved oil fields may be installed in a permanent manner and considerable expense is justified to make the pump stations efficient and economical. Here, electric drive and automatic control may be used. In new oil fields, the installation of pipe lines is usually very rapid, and manually operated equipment is used to insure quick procurement, installation, and service. Trunk lines for crude oil are usually of 8, 10, and 12 in. steel pipe. They usually serve a large producing area and are therefore seldom dependent entirely on any one oil field. Pumping stations on trunk lines, therefore, may be installed in a permanent manner and the expense of efficient and economical operation here again is justified. Trunk lines for natural and refined gasoline are usually of 4, 6, and 8 in. steel pipe, and being of a permanent nature, good pumping stations are justified. The trend has been to the use of seamless or welded steel pipe sections, which are either electric or gas welded at all joints. Two or more pipe lines are sometimes operated in parallel as one unit. The parallel lines, called loops, receive oil from a common manifold at one station and discharge it into a common manifold at the next station. Two or more parallel pipe lines also may be operated as separate lines to transport 2 or more grades of oil simultaneously.

The pumping pressures for trunk lines and main gathering lines for crude oil are usually from 525 to 800 lb per sq in., depending upon the strength of the pipe and the flow required. The pumping pressures for gasoline lines are, in general, somewhat lower. At present, pipe for approximately 800 lb per sq in. working pressure is the most common.

Trunk pipe lines range from 50 to 600 miles in length. The short lines are between oil fields and coastal shipping points or refineries. The longer lines are provided for transcontinental transportation. There are a number of short trunk lines between fields in the Southwest and the Gulf region and there are a number of long trunk lines between the same district and the Chicago and St. Louis districts. There is an 8-in. line some 680 miles long for transporting gasoline from a Texas refinery to East St. Louis.

Regular pumping stations are spaced from 25 to 100 miles apart along the pipe line, depending upon the topography of the country traversed and the rate of flow desired. Sometimes booster pump stations are installed between the initial pump stations to increase the rate of flow of existing pipe lines. The rate of flow, however, may not be increased above a certain critical value at which the flow becomes turbulent and the pipe friction losses increase considerably.

Pumping stations initially were provided with steam driven reciprocating pumps. The improvement of the diesel engine, the extension of electric lines, and the reduction of the cost of electric service within the last few years have resulted in the electric motor and the diesel engine practically superseding the steam engine for driving reciprocating pumps in main pumping stations. After the electric motor was accepted for pipe line pumping service the direct connected electric motor to centrifugal pump combination was tried with success, except that the efficiency of the standard centrifugal pump was low when used for pumping heavy oils. The centrifugal pump has been redesigned for oil pipe line pumping service and now has good efficiency. A high speed diesel engine with speed increaser is now available for use with centrifugal pumps.

Electric Drive

Within the last few years, more than 180,000 hp in large electric motors has been applied to pipe line pumping. With the further extension of rural electric service and with the application of automatic control, electric drive should have a decided advantage. Some of the present advantages of electric drive are: (1) the first cost is low; (2) a

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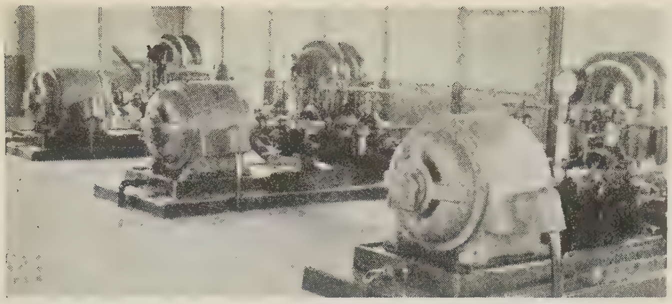


Fig. 1. (Left) Three 250-hp 3,600-rpm squirrel cage induction motors driving centrifugal pumps in pipe line pumping station for pumping crude oil

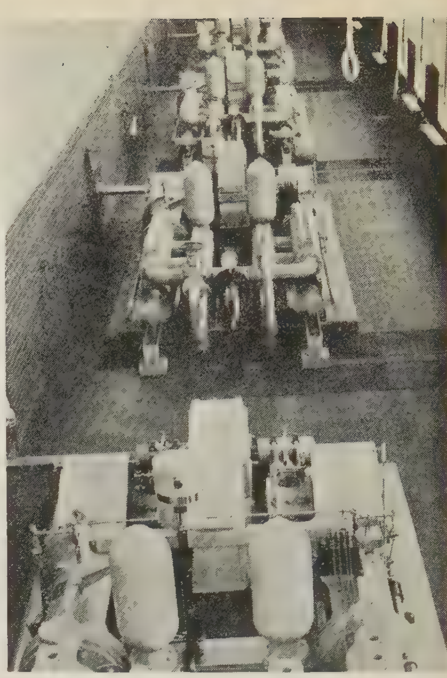


Fig. 2. Four reciprocating pumps in pipe line pumping station for pumping gasoline. The driving motors are located behind the left hand wall. See Fig. 3

minimum of labor is required; (3) electric power is available for station service and operators' cottages; (4) fewer station auxiliaries are required; (5) the value of non-salvable material is low; (6) a water supply is not required, as for engine operation; (7) the electric drive output is not affected by the altitude of the station; and (8) electric drive is the most susceptible to automatic control.

The types of motors commonly used for pipe line pumps are the squirrel cage induction and the synchronous motors. Both types are essentially constant speed motors. Variable speed may be obtained with the wound rotor induction or Sherbius induction motors or with the d-c motor combined with a motor generator set, but the increased first cost and the decreased efficiency have practically prevented such applications. Of the first 2 motors mentioned, the squirrel cage induction motor has the lower first cost, and it may be connected directly to the pump without the use of a firewall. In the larger sizes, the squirrel cage induction motor has a good power factor. The synchronous motor is somewhat more efficient than the induction motor and may be operated at unity power factor.

Pumping With Electric Drive

The principal difficulty encountered in the application of electric drive to oil pipe line pumping was the necessity of operating the pipe lines at varying capacities and with varying oil viscosities. If the quantity of oil to be pumped in 24 hr is less than the 24-hr capacity of the line, the pumps may be shut down for part of the day and the oil all pumped at one pumping, or the pipe line may be operated continuously at reduced capacity. The latter method is desirable because the efficiency of a pipe line increases with decreased flow, and if electric power is purchased on a demand basis the cost of power is reduced. Viscosity varies with the grade and temperature of the oil. The grade of oil may vary at any time because pipe line companies are common carriers and may be called upon to transport many grades of oil. Variations of temperature are more or less seasonal. If various grades of gasoline are pumped through the same pipe line, the gasoline must be kept moving to prevent contamination or intermixing.

The problem of variable pump output with constant speed drive has been attacked in several ways. A choice between parallel pipe lines of different sizes and characteristics sometimes may be made. A reciprocating pump, operating at a constant speed, has a positive displacement or capacity; the output may be varied: (1) by bypassing part of the output from the discharge to the suction line; (2) by changing the pump plungers; (3) by increasing or decreasing the number of pumps in operation; and (4) by the use of special reciprocating pumps. In the case of the centrifugal pump operating at a constant speed, there is a continuous flow which increases as the discharge pressure decreases; the output may be varied, (1) by providing a discharge throttle valve; (2) by changing the pump impellers; (3) by increasing or decreasing the number of pumps in operation; and (4) by the addition of a booster pump. The installation of a single stage centrifugal booster pump in series with the main centrifugal pumps, suitable for operation at full line capacity and for increasing the station discharge pressure a fractional amount provides an excellent means of varying the output. The booster pump must be provided with a wound rotor induction motor with the collector rings enclosed in an explosion proof compartment and with variable speed control. As the size of the booster pump and motor is small compared with the main pump units, the increase in first cost is small and the losses of the wound rotor induction motor are a small percentage of the total power used.

Pump and Pipe Line Characteristics

It is evident that in the consideration of automatic control, variable flow and viscosity are important items. The following 2 examples are used for illustration of these factors. The head-capacity curves of 2 similar reciprocating pumps separately and in parallel are shown in Fig. 4 superimposed upon the head-capacity curves of a pipe line for 2 values of oil viscosity. It is evident that for oil of viscosity No. 1, one pump alone has a capacity of $^1/_2\,C$ bbl per hr at a pressure P_2, while 2 pumps in parallel have a capacity of C bbl per hr at the normal

pressure P_n; one large pump may be used to secure the same result. However, for oil of viscosity No. 2, the discharge pressure for 2 pumps in parallel is P_1 which is less than the normal P_n, while the capacity of the pumps is C bbl per hr as before. If larger pumps had been provided it would have been possible to pump oil of viscosity No. 2 at an increased capacity or $C + C_1$ bbl per hr without the discharge pressure exceeding the normal pressure P_n. If larger pumps are used, it is necessary in the case of oil of viscosity No. 1 to decrease the discharge pressure from the abnormal value P_a to the normal pressure P_n by means of a bypass valve or by readjusting a special pump, if such a pump is used. In practice, some variations of pressure and capacity are permissible and are disregarded when the quantity of oil to be moved does not require the operation of the pipe line at its absolute maximum capacity.

The head-capacity curves of 2 similar centrifugal pumps separately and in series are shown in Fig. 5. It is evident that, for oil of viscosity No. 1, one pump alone has a capacity a little in excess of $^2/_3\,C$ bbl per hr at a pressure of P_2, while 2 pumps in series have a capacity of C bbl per hr at the normal pressure P_n. However, for oil of viscosity No. 2, the discharge pressure for the same 2 pumps in series is P_1 and the capacity is $C + C_1$ bbl per hr. It is evident that the centrifugal pump in this respect is better than the reciprocating pump because with the change in viscosity the difference between P_1 and P_n is less and the capacity of the pump increases an amount C_1 bbl per hr without separate adjustment. It is sometimes desirable to operate the pipe line at its maximum capacity by increasing the pump capacity the amount C_2 which is possible without the discharge pressure exceeding the normal value P_n. This increased capacity may be accomplished by using larger pumps, although it then is necessary in the case of oil of viscosity No. 1 to decrease the discharge pressure from the abnormal value of P_a to the normal pressure P_n by means of a throttle valve. An increase of pump size would increase the first cost and would decrease the efficiency for other than oils of viscosity No. 2 and it would be more desirable to install the single stage centrifugal booster pump previously described. The maximum head required of the booster pump is a value $P_n - P_4$ for oil of viscosity No. 2 and the minimum head is zero for oil of viscosity No. 1. This head is varied by varying the speed of the wound rotor induction motor which drives the booster pump. It should be noted that the booster pump is completely shut down for oil of viscosity No. 1.

Fig. 3. Four 125-hp 277-rpm synchronous motors and control equipment for driving the 4 reciprocating gasoline pumps shown in Fig. 2. A firewall separates the pump room and the electrical equipment

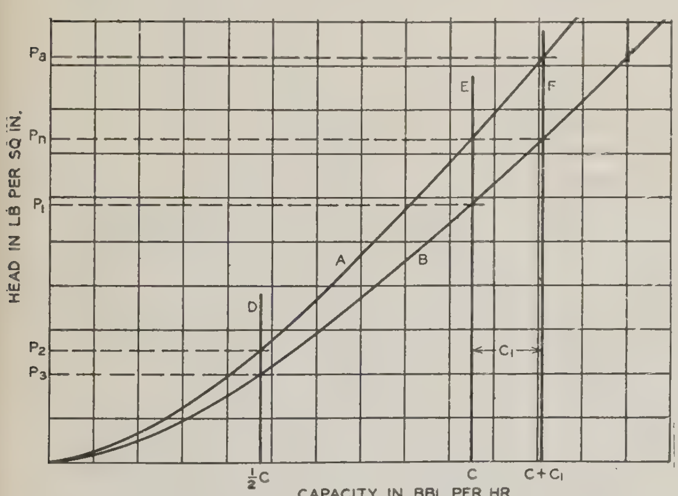


Fig. 4. Head-capacity curves of 2 similar reciprocating pumps superimposed upon the head-capacity curves of a crude oil pipe line for 2 values of oil viscosity

Curve A. Pipe line characteristics for viscosity No. 1
Curve B. Pipe line characteristics for viscosity No. 2
Curve D. Characteristic of single reciprocating pump
Curve E. Characteristic of 2 similar reciprocating pumps in parallel
Curve F. Characteristic of 2 similar reciprocating pumps in parallel of larger size than for Curve E

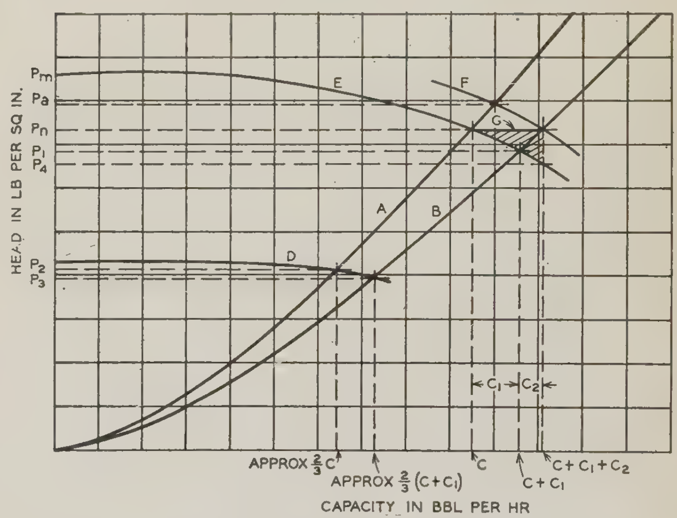


Fig. 5. Head-capacity curves of 2 similar centrifugal pumps superimposed upon the head-capacity curves of a crude oil pipe line for 2 values of oil viscosity. The shaded area shows the effect of the variable speed booster pump when used

Curve A. Pipe line characteristics for viscosity No. 1
Curve B. Pipe line characteristics for viscosity No. 2
Curve D. Characteristic of single centrifugal pump
Curve E. Characteristic of 2 similar centrifugal pumps in series
Curve F. Characteristic of 2 similar centrifugal pumps in series of larger size than for Curve E
Curve G. Characteristic which may be obtained by the use of a variable speed booster pump in series with the pumps of Curve E

If a pipe line is closed off or becomes blocked on the discharge side of a reciprocating pump, a considerable pressure rise will result because the pump has a positive displacement. Relief valves often are installed to bypass oil from the discharge to the suction side of reciprocating pumps to prevent abnormal pressure and the resulting damage to pipe line and equipment. This is not necessary for the centrifugal pump because the pressure can never exceed the valve P_m corresponding to zero capacity. Regardless of these limits of pressure, it is considered good practice to shut down either type of pump immediately on the occurrence of high pressure.

If a pipe line is partially or entirely empty on the discharge side when a pump is started, the discharge pressure will be low because there will be little or no line back pressure. A reciprocating pump under such a condition will pump full capacity at decreased power until the discharge pressure is established. A centrifugal pump, if sufficient oil is available, will pump excessive capacity at increased power until the pipe line is filled and the normal discharge pressure is established. Unless the pump is specially designed to prevent severe overload and possible damage to the pump and motor, it is customary to maintain satisfactory pressure within the centrifugal pump by means of a discharge throttle valve until the back pressure of the line is established. The operation of this throttle valve may be either manual or automatic.

It is generally accepted that the reciprocating pump is somewhat more efficient than the centrifugal pump, while the centrifugal pump has a lower installed first cost; both types will continue to be used. Automatic control may be applied to either type. Although it is not considered good practice to use centrifugal and reciprocating pumps either in series or in parallel in the same pipe line at the same pump station, they may be used in series in the same pipe line when the pumps are located at different stations some distance apart, as it is customary to provide storage or surge tanks at reciprocating pump stations. Tanks may or may not be provided for centrifugal pumps. If tanks are not provided, the centrifugal pumps are inserted directly into the pipe line. Sometimes tanks are provided at pump stations for storage and for gaging. Tanks for gasoline pipe lines, if used, must be either pressure tanks or tanks with floating roofs, to prevent vaporization.

Pump Station Arrangement

The arrangement of pumps and equipment at pipe line pumping stations varies. An arrangement for a reciprocating pump station and one for a centrifugal pump station are illustrated in Figs. 6 and 7. These arrangements are suitable for automatic control. The figures were prepared on the assumption that 2 reciprocating pumps in multiple or 2 centrifugal pumps in series would be required to obtain full pipe capacity. Spare pumps R-3 and C-3 have been added, although these often are omitted. A booster pump C-4 may or may not be provided at the centrifugal pump station. Each pump station shown is provided with a bypass line by way of gate valve GV-2, check valve CV-1 and gate valve GV-3, so that when gate valves GV-4 and GV-5 are closed the station is completely isolated. This arrangement is advisable for fire protection. The building is arranged so that all oil leakage within the building drains into the sump. A strainer, as shown, is usually provided ahead of the pumps to catch particles in the oil stream which might damage the pumps. Each pump is provided with gate valves which may be closed to isolate the pump for inspection or repair. It is not necessary to close the individual pump gate valves when a pump is shut down because the resistance of the bypass is so low that the oil will flow through it rather than through the pump. If all the valves shown are left open, any pump may be started or stopped at will without operating a single valve, thus greatly simplifying the design of automatic control. The only exception is that, although not absolutely necessary, it might be considered good practice to close gate valves GV-4 and GV-5 when the station is completely shut down. All electrical equipment may be arranged in any manner approved for an atmosphere, which, within the pump house, is considered inflammable. The automatic control switchboards may be placed in the main pump room or in a small enclosed switch room. The latter location is undoubtedly the better. Control circuits may be run through conduit to the circuit breakers or electrically operated switches. Control circuits may also be provided for motor operated valves when the expense of such valves is justified. The gate valves GV-4 and GV-5 should be motor operated in a completely automatic station for the sake of fire or blown gasket protection.

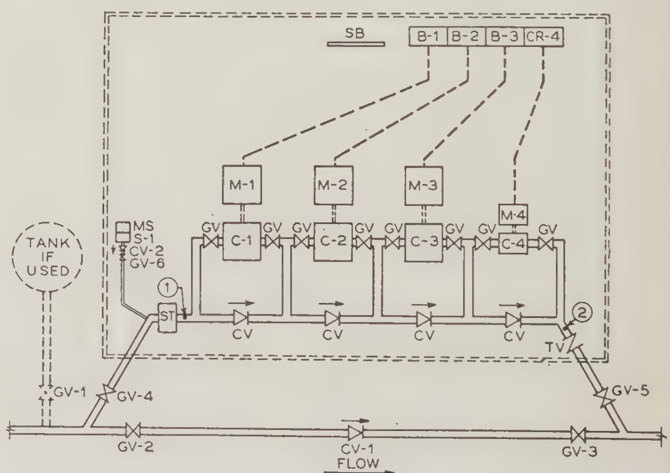


Fig. 6. Arrangement of pipe line pumping station with reciprocating pumps and automatic control

R-1, R-2, R-3	Main reciprocating pumps
M-1, M-2, M-3	Main pump motors
B-1, B-2, B-3	Control equipment for main pump motors
CV-1, CV-2	Check valves
GV, GV-1, GV-2, GV-3, GV-4, GV-5, GV-6	Gate valves
S-1, MS	Sump pump and motor, respectively
BV, RV	Bypass and relief valves, respectively
SB	Switchboard
ST	Strainer

Automatic Control

Automatic control of oil pipe line pumping may be given 3 classifications, (1) complete automatic protection at an attended station; (2) complete automatic control as well as protection, with the station unattended except for one watchman-operator; and (3) complete automatic control and protection, with the station unattended. The first cost of equipment for the first type of station is less than for the second type, but 2 or 3 operators and operators' cottages are required. At such a station, an operator is always available for starting and stopping the station as directed by the pipe line dispatcher or by the indication of meters within the station. The first cost of equipment for the second type of station may be somewhat higher than for the first type, but only one operator and operator's cottage are required. This type of station starts and stops automatically and is provided with complete automatic protection and the operator has nothing to do with the normal operation of the station other than maintenance and miscellaneous duties. Some of the large oil pipe line companies may never consent to have their main line pump stations entirely unattended; in a pipe line system the entire business of that pipe line passes through each pump station on the line and, if a pump station is crippled, the entire pipe line is crippled. The third type of station does not require operators or operators' cottages and is especially suitable for small pump stations on gathering lines. This type of station is provided with complete automatic control and protection as is provided for the second plan with perhaps the addition of one or two items. For example, in the case of a shut down by a protective device, a telephone signal might be provided to sound a loud speaker in the dispatcher's office. This signal may be only a series of impulses superimposed on the telephone circuit. Regardless of which one of the 3 types of stations is used, it is advisable to have a qualified man make regular tours of the stations for inspection and adjustment.

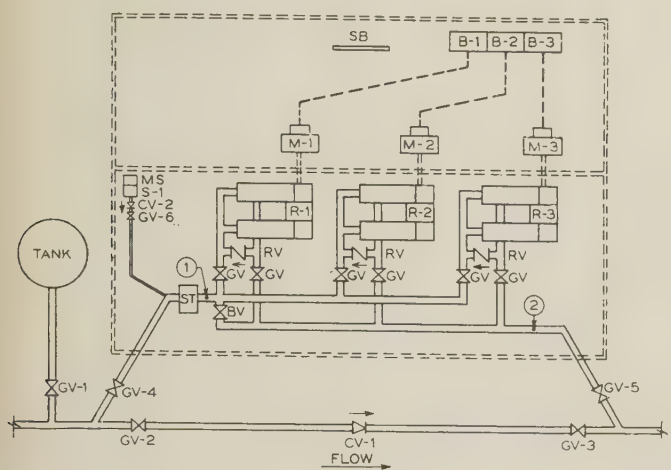


Fig. 7. Arrangement of pipe line pumping station with centrifugal pumps and automatic control

C-1, C-2, C-3	Main centrifugal pumps
M-1, M-2, M-3	Main pump motors
B-1, B-2, B-3	Control equipment for main pump motors
C-4, M-4, CR-4	Booster pump, motor and controller, respectively
CV, CV-1, CV-2	Check valves
GV, GV-1, GV-2 GV-3, GV-4, GV-5, GV-6	Gate valves
S-1, MS	Sump pump and motor, respectively
TV	Throttle valve
SB	Switchboard
ST	Strainer

Protection and supervision are the most important phases of automatic control of pipe line pumping stations. The methods of starting, operating, and stopping have been satisfactorily worked out by the electrical industry for all types of motors commonly used in pipe line pumping. Therefore, these methods, together with the types of circuit breakers or compensators used and the types of relays required, will not be discussed.

Automatic Protection

Only such protection as is absolutely necessary and economically justifiable should be applied. Automatic control for pipe line pumping stations may include protection against (1) fire, (2) blown gaskets or pipe leakage, (3) low suction pressure, (4) low discharge pressure, (5) high discharge pressure, (6) overheated bearings, (7) overloaded pumps and motors, (8) undervoltage operation or voltage failure, and (9) all protection regularly provided for the type of drive motors used. It is necessary to close the outside main gate valves *GV*-4 and *GV*-5 only in case of the first 2 of these types of failure.

Protection against fire might consist of fusible links connected into the control circuits at points where fire might occur; they would shut down the station, isolate it from the pipe line, sound an alarm, and cause the release of fire extinguishing gas or fluid if provided. Protection against blown gaskets and oil leakage has been provided by placing deflectors around the pump flanges and couplings in such a manner that oil leakage is caught and conducted to the station sump. There are 2 float switches in the sump, one to control a small motor driven pump capable of keeping the sump clear of oil under normal conditions, and the second to shut down the station and close the outside main gate valves.

Low suction pressure indicates that the upstream pump station has shut down, or that the upstream pipe has burst or has been shut off and that there is not sufficient oil for the safe operation of pumps; protection is achieved by attaching a low pressure relay at point 1 on Figs. 6 and 7. After being shut down by this relay, the station may be started automatically or by manually resetting the relay. When a pump is starting, low discharge pressure indicates that the downstream pipe is partially or entirely empty, while later it indicates that this line has burst. The low pressure relay may be attached

at point 2 on Figs. 6 and 7. A high discharge pressure relay is provided to prevent either the bursting of the downstream pipe line by excessive oil pressure or the overheating of the pumps when operating on a closed system. Operation of the low or high discharge pressure relay shuts down the station as described for the low suction pressure relay.

Bearing thermal relays are provided. Protection against overloaded pump and motor is accomplished by the use of machine thermal or overcurrent relays. Bearing and machine relays are set rather high and are arranged to prevent operation until an inspection is made. Control circuits may be arranged to start a spare pump unit concurrently with the shutting down of a defective unit. Protection against undervoltage operation or voltage failure may be provided by the use of standard relays.

Remote and Supervisory Control

Operation of pumping stations may be supervised either by direct control, by which is meant both remote control and standard supervisory control, or by prearranged control. With either form of direct control, operation of the station at all times is under control of an operator at a nearby station or central point. Standard equipment for either type of direct control has been developed and may be applied satisfactorily to pipe line pumping stations.

The terminal equipment for supervisory control is more expensive than for remote control, but the reduction in number of wires between the station and the control point results in supervisory control being the cheaper for long distances. Remote control is not generally economical for distances of over 2 or 3 miles, while supervisory control, requiring only 2 connecting wires, will operate for distances up to 100 miles. Existing telephone circuits may be used for some forms of supervisory control. Either type of direct control permits indication at the control point of the operation of equipment at the controlled station.

Prearranged Control

Prearranged control is considerably cheaper than direct control, as it consists of automatically initiating within the pump station the impulses to control the equipment without the assistance of an attendant. Float switches, pressure relays, flow relays, and similar devices are used to initiate these impulses.

A very simple method of prearranged control is possible when a storage or surge tank is located at the pump station. The tank in this case is connected to the pipe line and the amount of oil in the tank is an indication of whether 1 or 2 pumps should be operated or not. If, for any reason, the pump station is shut down by a protective device, the motor operated gate valve in the pipe line connection to the tank may be closed automatically and if sufficient pressure is developed by the first pump station upstream, the oil will pass on at reduced velocity by way of the bypass.

Prearranged control may be applied to new booster stations with centrifugal pumps but without tanks, installed between 2 existing manually operated pump stations. The manual stations maintain normal flow and the booster stations are started to increase the flow when a large quantity of oil is to be moved. Automatic control has been applied to this type of pump station in 2 ways: by the use of pressure relays alone and by the combined use of pressure and flow relays. The pressure relays may be attached at point 1, and the flow relays may be installed at point 2, as indicated in Figs. 6 and 7.

The operation of the pressure relays when used alone is based upon the hydraulic gradient of the pipe line. The booster station is provided with 2 pressure relays for starting and stopping, 1 for each pump. One of the pressure relays is set to close at a pressure somewhat higher than the normal pressure at this booster station when it is shut down. If this relay remains closed for several minutes the first pump is started; time delay is provided to prevent false operation on surges. The operator at the first station upstream therefore starts the first pump at the booster station by increasing the discharge pressure at his station for several minutes. This results in a rise of pressure along the pipe line, operating the relay at the booster station. The operator at the upstream station may start the second pump in a similar manner. A decrease in pressure at the upstream station indicates to the operator that a pump at the booster station has started. Lowering the pressure at the upstream station for several minutes permits the stopping of one or both booster pumps, as desired.

The use of pressure relays for starting and flow relays for stopping the pumps at the booster station is similar in operation to the scheme just described. A scheme also has been developed for operating 2 or more automatic centrifugal pump stations in series by prearranged control when the pumps are placed directly in the pipe line without tanks. This plan provides for the use of centrifugal pumps of similar characteristics throughout.

Conclusions

Experience already obtained with electric drive and automatic control for pipe line pumping stations enables the following conclusions to be drawn:

1. The pumping of crude oil and gasoline through pipe lines is an industry which is growing rapidly and is becoming an important customer of both electric utilities and manufacturers.

2. Electric motor drive for pipe line pumping is in competition with internal combustion and steam engines and improvements in electric service and electric drive must keep pace with improvements in the competing elements.

3. The electric motor is fundamentally high speed and is suitable for use with the centrifugal pump.

4. Automatic control of pumping stations on trunk and main gathering pipe lines is successful and will be a factor in decreasing the cost of pumping by electric power.

5. Pipe line equipment is amortized more rapidly than equipment in most industries and it usually is desirable to keep the first cost of equipment as low as possible.

6. Most pipe line companies probably will require one operator-watchman at each pump station regardless of automatic control. There should be no question about the future employment of all present employed capable operators.

Welded Sheet Steel Roof Reduces Construction Costs

CONSIDERABLE reduction in cost has been secured through the use of arc welded steel roofs for 4 huge grain elevators built by the Port of New York Authority at Albany, N. Y. It is possible for similar construction methods to be used in other types of structures.

Grain elevators previously constructed have large areas left open between the hollow cylindrical concrete storage spaces. At Albany, however, it was decided to cover these areas with water-tight steel roofs, thus greatly increasing the amount of storage space. To keep construction costs to a minimum, sheet steel roofing was used without intermediary support between the ends of the suspended sheets.

The roof slants upward at an angle of between 30 and 40 deg. Steel strips supported only at the top and bottom form a catenary curve 140 ft in length. Each of the 4 roofs is 288 ft wide, composed of 76 sections of 12-gage mild steel sheets, 50 in. wide. These strips overlap each other 2 in. and are welded together. The lower part of the roof starts on a ramp approximately 22 ft above the ground.

Each section, 140-ft long and 50-in. wide, is assembled on the ground from several sheets of various lengths. These had been ordered in lengths of 5 ft, 10 ft, and 31 ft 3 in., and are welded together in a jig. The seams between the sheets were butt welded, except one which was lap welded to compensate for any expansion and contraction resulting from the butt weld. On completion of the section, the lap weld was tack welded on the under side.

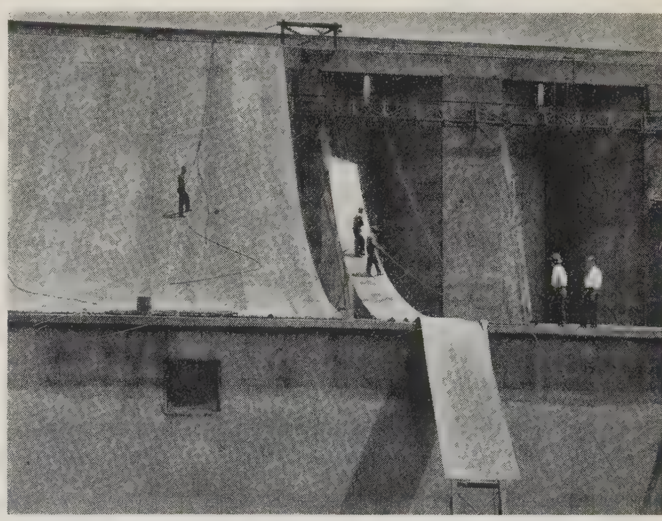
Two rows of 7/8-in. bolt holes were located at the ends of each section, the outside rows being for erection purposes and the inside rows for anchoring to the supports. Two steel cables suspended between the upper and lower ramps supported the section as it was drawn upward. To serve as a guide while hoisting, a bar with 2 U-bolts welded in place so that they would pass over the 2 cables, was bolted to the roof section. As the sections were hoisted into place the inner row of holes in each section was fitted over 7/8-in. bolts anchored in the concrete at the top of the ramps. Alternate sections of the sheet steel roof were first erected, leaving a gap of 46 in., over which the intermediate sections were then drawn up. Guide cables were not required for the intermediate sections. Boards were placed across the gap while the intermediate sheets were being raised.

After the sheets were raised they were first joined by tack welding, to restrain expansion and contraction and to prevent unevenness in the plates. After all sections had been tack welded, continuous welds were laid along each seam, the step-back method being used to dissipate heat and prevent distortion.

Small expansion joints were welded in place over the longitudinal seams at every tenth seam, giving the roof free expansion. These joints were of 14-gage steel running one-half the length of the seam, and staggered on upper and lower sides of the roof.

Welding was done by the "shielded arc" process using 5/32-in. Fleetweld electrodes with a current of 150 amp at 32 volts. With a total of 8 operators, the speed of welding averaged 40 to 50 ft per hr. Welding and the erection of the roofs were done by the J. K. Welding Company, New York, N. Y.

Grain elevator for the Port of Albany, N. Y., showing the first few sections of the electric arc welded steel roof in place. 60,000 lineal ft of welds were required to complete this unusual roof which hangs in a natural catenary between the top and bottom ramps, no intervening supports being used. It is reported that the cost of storage space per bushel of grain was reduced nearly 75 per cent through the use of this type of roof



Drawing up one of the 140-ft sheet steel sections comprising the roof of the new grain elevator at the Port of Albany, N. Y. During erection this section is supported on 2 cables; the intermediate section which will next be drawn up to fill the gap requires no cables for support as it overlaps the sections already raised. 400 tons of steel were used in the construction of the roofs

Lightning Experience on Wood Pole Lines

Operating experience with many electric power lines of various types utilizing wood as lightning insulation, has demonstrated that ordinary wood can be used to advantage in combination with other measures for improving the lightning performance of lines. In this article are outlined the results of a careful analysis of this operating data and the pertinent conclusions drawn therefrom. Methods of construction offering the greatest promise at present are: diverting the lightning strokes so as to prevent flashovers to the power conductors; draining the lightning from the power conductors through fast operating dynamic follow current interrupting devices; and a combination of these 2 methods.

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Fig. 1. Lightning damage to the top and base of an unprotected wooden transmission line structure (after temporary repairs)

WITH the active initiation of lightning investigations a few years ago, the importance of having data on the impulse characteristics of insulation and of a better understanding of the use of insulation available in construction came to the fore. Wood long had been recognized as having insulating properties, as indicated by application in line construction, use in the manufacture of apparatus, and laboratory tests. To gain a better measure of the impulse strengths of various amounts and kinds of wood as they might be used in line construction and under varying conditions of contamination and moisture, a series of tests was conducted early in 1928; the results of which were presented to the Institute by the author at the Pacific Coast convention in 1929.[1] (For references see list at end of article.) The results of these tests held considerable interest, inasmuch as relatively high insulation strengths were indicated for lightning voltages for practically all of the ordinary kinds of wood, under practically all expected service conditions. It was indicated also that wood could be protected from damage by the use of bypass protecting air gaps. Furthermore, it seemed practicable to increase materially the lightning insulation strengths of lines supported by wooden structures, by rather simple and inexpensive methods. Accordingly, ideas developed from these data were applied in an experimental manner in the construction of several lines, to determine from actual experience what service improvements might be realized, and for the purpose of contributing to lightning research results.

These transmission lines under trial, totaling approximately 1,300 miles of line on several systems, are representative of most of the severe lightning conditions in the United States. Space does not permit, nor would interest justify, describing and tabulating the results in detail. Therefore, it is believed sufficient to show several typical illustrations with brief descriptions of the construction, and present only the more important results and the pertinent conclusions drawn from the carefully collected data and observations. With knowledge concerning the mechanism and magnitudes of lightning still incomplete, it is of course impracticable to make the statements positive or final.

Description of Experimental Construction

When it is considered that lightning voltages are of sufficient magnitude to break down great distances

Full text of "Operating Experience With Wood Utilized as Lightning Insulation" (No. 33-28) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23-27, 1933.

through air, and strokes terminating on wooden structures will do damage as illustrated by Fig. 1, little hope can be entertained of stopping lightning with insulation alone. However, it was thought that possibly some lightning surges of lesser voltage and current magnitudes (including induced voltages of 50 to 75 kv per ft of conductor height, and possibly mild branch strokes) might appear on lines and be held by high insulation, thus reducing line tripouts.

First trials consisted of simply increasing the insulation of the 3 phases to ground by substantial amounts. In Fig. 2 is illustrated a 66-kv line in Kansas, with 9-ft guy insulators and 3-ft 8-in. protecting gaps in multiple to ground, mounted on the pole. Initially, unprotected 7-ft gaps between bands wrapped around the poles were used on all structures, similar to those illustrated in Fig. 6. Pole gap damage was so severe, however, that protecting horn gaps later were added across 10-ft pole gaps. Frequently from 3 to 6 consecutive poles were flashed by what probably was a single lightning discharge. Surge voltage recorders were connected to this section of line for $1^1/_2$ seasons before and $3^1/_2$ seasons after the guy insulators were installed.

Two 66-kv lines in Pennsylvania were equipped with 9-ft wooden guy insulators with protecting horn gaps mounted on the insulators. About $^1/_3$ of the guy insulators were of the type illustrated by Fig. 6 with protecting gaps of 6 ft 6 in.; the others were similar to those shown in Fig. 2 with protecting gaps of 3 ft 7 in. Surge voltage recorders were connected to one of these lines for one season, and to a line similar in construction except for the guy insulators for 2 seasons.

Several H-frame 110-kv lines constructed in Arkansas, Louisiana, Mississippi, Carolina, Tennessee, and Mexico, also some 66-kv construction in Carolina, employed 18- to 24-ft guy insulators. This construction is illustrated in Figs. 3, 6, and 8. Protection for the guy insulators on all of these lines was provided by gaps mounted on the poles. On the first line with 2 9-ft guy insulators in series, a pole gap of 13 ft 6 in. was used between bands wrapped around the poles, as shown by Fig. 6. On all subsequent construction, protecting horn gaps were applied. For the lines employing 2 9-ft or one 18-ft insulator the protecting gaps were 7 ft 2 in. across 20 ft of pole with a clearance of 3 ft 6 in. between the tips of the horns and the wood. On a line with 2 12-ft guy insulators, the protecting gaps were 9 ft 3 in. across 26 ft of pole with a clearance to the horn tips of 4 ft 6 in.

Guy insulator and pole gap protection has been accomplished with the foregoing protecting gap dimensions in a great many cases. On the 50-mile Tennessee line with 2 12-ft guy insulators, where some damage was experienced, the guy anchor rods were connected to the pole butt grounds, also half of the gaps were shortened to 8 ft and half to 7 ft. On a line in Louisiana with 18-ft guy insulators, the protecting gaps were shortened to 5 ft 9 in. These changes have practically prevented further damage.

Use of the crossarm insulation varied: On some lines the entire length was employed in order to maintain the maximum possible phase-to-phase insulation as well as to ground; on others only the end sections were bonded to the top of the protecting gaps; and in some cases, the entire arm was bonded to prevent crossarm damage. On about $^1/_3$ of the lines, the unguyed structures utilized the full pole and crossarm insulation; on another third, the amount of wood utilized was about the same on all structures and protection was provided initially for the wood; and on the remainder, provision was made for the future installation of pole protecting gaps.

Another application of protecting gaps is illustrated by Fig. 4. Several lines in Texas with conventional overhead ground wires were equipped in

Fig. 2. Wooden structure on 66-kv line with 9-ft guy insulators and 3-ft 8-in. pole protecting gaps (left)

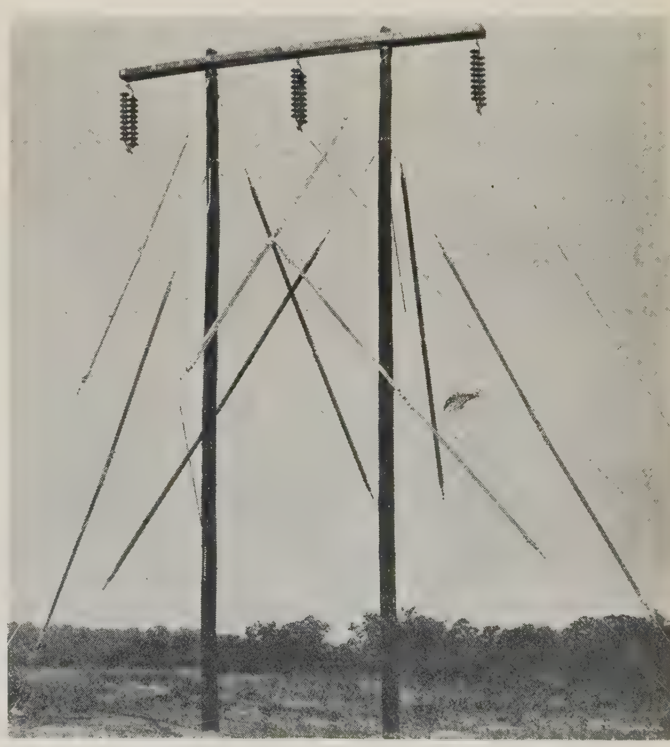

Fig. 3. Structure on 110-kv line with wooden guy insulators of 2 12-ft sections, and 8-ft pole protecting gaps (right)

this manner so as to utilize the insulation of the crossarm and at the same time protect the arm from damage by those lightning strokes that are not diverted successfully. Other lines made full use of the crossarms and adequate clearances were maintained between conductors and guys; also guy insulators were employed to a limited extent. On one of these lines on the Texas Power & Light Company system, operating at 132 kv, surge voltage recorders were connected for 2 seasons.

In Figs. 7 and 8 are illustrations of the so-called drainage scheme, described in a paper presented by Pittman and Torok in 1930.[2] In this scheme the crossarm insulation is used to provide the margin necessary for directing the lightning flashes through the dynamic follow current interrupting devices. Wooden guy insulators were used in the design of particular structures. It might be added that if experience indicates the probability of lightning striking the ends of the crossarms with resultant damage, pole bayonets sufficiently high to intercept the strokes may be advisable. Three 110-kv lines of this design are in operation in Arkansas and a section of 110-kv line in Tennessee. Also a limited application of dynamic current interrupting devices has been made on distribution lines.

In the lightning diversion design illustrated by Figs. 9 and 10 the full insulation of the crossarm is utilized; also guy insulators are employed with certain structures. The following features of this 70-mile 132-kv line of the Texas Power & Light Company may be of interest: normal span length, 550 ft; approximate clearance between diverting cables and conductors at midspan, 20 ft; steel lightning diverting cables bonded together at top of structure; pole butt grounds bonded together by buried wire at base; lightning insulation of 9 suspension units plus 7 ft of crossarm, equivalent to about 16 insulator units. Ground resistances per structure (2 pole butts in parallel) were as follows: 40 per cent less than 25 ohms each; 40 per cent between 25 and 100 ohms each; and the remainder more than 100 ohms each.

Another use of wood in the application of lightning diverting cables is found on the Wallenpaupack-Siegfried 220-kv line in Pennsylvania.[4] The diverting cables are supported by wooden poles mounted on top of the steel towers and are grounded through the system of guys. With this design the poles provide the insulation to prevent the lightning current from being conducted through the tower.

Fig. 4. Top of a 66-kv structure with conventional overhead ground wires and crossarm protecting gaps

Operating Results

Surge voltage recorders on the 66-kv lines in Kansas and Pennsylvania, utilizing the equivalent of about 7 ft of wood in series with 70-kv-rated pin insulators, yielded several records of from 1,000 kv to more than 1,800 kv. The higher value represented the recorder limit with the potentiometer ratio used; this voltage was recorded 7 times for lightning flashovers on the line $1/4$ to $1\frac{1}{2}$ miles away from the instruments. Maximum records of approximately 600 kv were obtained for an insulator plus about one ft of pole or 2 ft of crossarm. Likewise on the 132-kv line in Texas, several records of from 1,000 to 2,200 kv were obtained for 9 suspension units plus 7 ft of crossarm. The stroke giving the 2,200-kv record, occurred 7,500 ft from the recorder. Cathode ray oscillograms of 4,500 kv and 5,000 kv obtained on a section of line in Arkansas where all guys were removed, have been reported previously;[2] the strokes producing these records flashed approximately 45 ft of wood and occurred 2.3 miles and 4.0 miles, respectively, from the oscillograph.

The foregoing records provide ample confirmation that wood has lightning insulation strength. The maximum voltages were considerably in excess of the values obtained in the laboratory with the $1/4 \times 20$-μsec impulse wave, and indicate front-of-wave flashovers for extremely fast rates of voltage rise. They should not, however, be interpreted as measurements of lightning stroke voltages, but rather the lightning strengths of the insulation, as are practically all other records that have been obtained in a similar manner. A speculation of possible interest is that if a liner relation between insulation strength

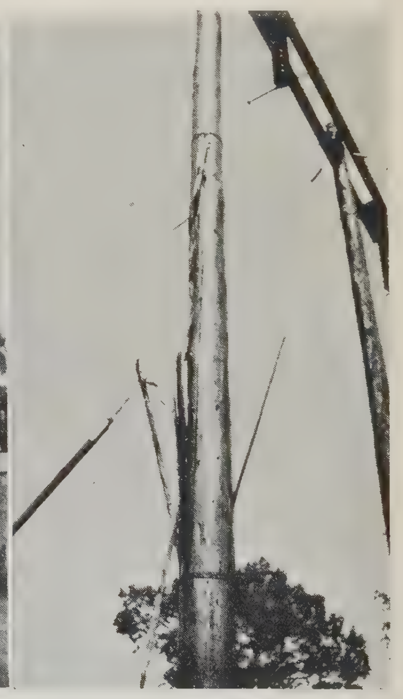

Fig. 5. (Left) A damaged 9-ft wooden guy insulator with a 6-ft 6-in. protecting gap

Fig. 6. (Right) Lightning damage to a 13-ft 6-in. unprotected pole gap; 18-ft guy insulators

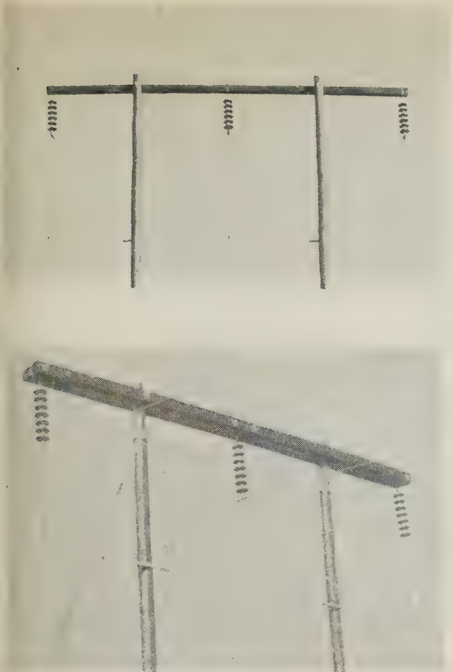

Fig. 7. Top of unguyed (above) and guyed (below) 110-kv line structures with arc interrupters

Fig. 8. Angle structures on 110-kv line with arc interrupters

and pole length holds, the voltages that could be measured across a wooden structure of ordinary height would be of the order of from 12,000 to 15,000 kv.

Few surge records of lightning voltages were obtained in the band between the flashover voltage of ordinary line insulators and that of the high lightning insulations developed by the use of wooden guy insulators; also line tripouts were coincident with practically all of the high-voltage records. This indicated that few lightning voltages appeared on the lines that were not of sufficient magnitude to cause flashover. In many instances when line tripouts occurred, relatively low surge voltages were recorded on some of the instruments because in general only attenuated values were recorded on account of the spacing of the instruments.

Carefully analyzed tripout records for several lines equipped with long wooden guy insulators and having lightning flashover strengths of from 1,500 to 3,500 kv, compared with otherwise similarly constructed lines having less than $^1/_2$ of these insulation strengths, have not indicated any appreciable decrease in the number of tripouts with the higher insulation. With the longer guy insulators and lower operating voltages however, there is some evidence to indicate that dynamic follow current may be slightly less frequent than on conventionally insulated lines. This method of attack for improving line performance does not appear as advantageous as do the diversion and drainage schemes.

High lightning insulation combined with lightning diversions cables properly located and grounded, somewhat as illustrated by Figs. 9 and 10, is proving effective. The 132-kv 70-mile line of the Texas Power & Light Company has not tripped out in one year of operation. As storms are prevalent in that territory, there is little doubt that the line has been exposed to lightning; a conventional 66-kv line of about the same length, in the same locality, and paralleling it for part of the distance, has been interrupted 26 times by lightning in the same period. This should not be interpreted as a statement that the line is immune to lightning flashover, as the right strokes may not have occurred at the right points; however, the performance indicates progress and possibilities. On the Wallenpaupack-Siegfried 220-kv line, records indicate 2 or possibly 3 direct strokes to the experimental lightning diverting cables in $2^1/_2$ seasons without line tripout.

Utilization of the crossarm insulation in combination with conventional overhead ground wires, as illustrated by Fig. 4, also is proving effective in the diversion of lightning strokes, though other design features are essential for best results.

The drainage scheme likewise is showing considerable promise. Records from the 3 110-kv lines in Arkansas are as follows: The 60-mile line with drain points at each structure has tripped out 4 times in approximately one year; 3 of these tripouts could be traced to failure of the arc interrupting devices or their mountings, both of which still were distinctly in the development stage when installed. The 45-mile line with drain points spaced approximately $^1/_2$ mile apart, and with no crossarm bonding or pole grounding wires on intermediate structures, has tripped 6 times in about $^2/_3$ of a lightning season, for which failure of the devices can be held almost entirely accountable. With this spacing both the lightning current discharges and dynamic follow current are concentrated through 1 or 2 devices. The duties imposed on this line have been found to exceed the capacities of the devices as originally installed. The third line of 28 miles is the one on which the first experiments were conducted.[2] Drain points were spaced about 2 miles initially; later the spacing was decreased to 1 mile, and finally to $^1/_2$ mile on $^2/_3$ of the line. The record of this line for $2^1/_2$ years since the shorter separations have been in service has been exceptionally good, only 2

Fig. 9. Top of a 132-kv structure with lightning diverting cables

interruptions occurring due to lightning on the drained sections.

Performance of lines on the same system with comparable construction, except for the application of the arc interrupting devices, has averaged 25 tripouts per 100 miles per year during the same periods. This would give an expected number of tripouts of 15, 11, and 5, respectively, for the 3 lines for one season. Careful examination at the middle of the 1932 lightning season of the tell-tale devices employed on the 60-mile line indicated 7 successful operations of the drainage system.

Protection of the wood when used as lightning insulation has been accomplished successfully; the ratios and dimensions given in the following paragraphs appear to be satisfactory for practical application.

Protecting horn gaps mounted on guy insulators or poles should have a ratio of *air gap length* to *net length of wood* of 0.35, and a ratio of *clearance from horn tip to wood* to *net length of wood* of 0.20.

Guy insulator protecting gaps mounted on the poles should (1) span a section of pole equal to or greater than the clear wood in the guy insulators (2) have the same clearance ratio as indicated in the preceding paragraph, and (3) have a ratio of *air gap length* to *net length of wooden guy insulator* of 0.30.

Uncertainties of voltage distribution with different combinations of insulators and crossarms complicate the problem of crossarm protection. Data are not sufficiently complete for offering general ratios. However, from experience on about 250 miles of line for most of 2 lightning seasons this much has been learned: with 5 suspension insulator units plus 4 ft of clear crossarm with a ratio of *air gap length* to *net length of wood* of 0.38, one arm has been damaged; similarly with 5 suspension units and 6 ft 6 in. of crossarm and a ratio of 0.33, one crossarm has been damaged.

On lines with conventional overhead ground wires, damage to unprotected crossarms generally is not severe. This probably is accounted for by the ground wires usually intercepting and carrying the major portion of the lightning current, even though the flash also may contact the conductors in the span or at the structures.

Sections of the wood in crossarms frequently can be used advantageously to minimize insulator damage and at the same time to increase impulse insulation strengths without unduly exposing the wood to lightning damage. This practice has been followed, unintentionally in many instances, for many years; but improvements are possible through the proper proportioning of the crossarm wood in series with the insulators, so that lightning flashes and dynamic follow current generally will not occur directly across the insulators and wood.

With the high lightning insulations obtained through the use of wood, substation protection usually is imperative. This has been accomplished quite effectively by the use of spillway gaps at line entrances, with settings for lightning flashover at some voltage lower than the insulation level of the station equipment and buses. These settings, and the types of gaps and their locations, are still in an experimental stage, inasmuch as experience and laboratory data, as well as the determinations of insulation level requirements, are not complete.

Conclusions

Only the more important conclusions are outlined which are considered sufficiently well substantiated for practical application in the utilization of wood as lightning insulation. They are drawn from a large amount of operating data and from the results of surge voltage investigations on specially designed wood lines as well as on conventional construction, accumulated on several representative transmission systems operating in severe lightning territories. Further, it is believed that these conclusions represent the summarized thought of the engineers responsible for conducting these coordinated investigations, as well as that of the manufacturing company engineers who have participated in reviews of the

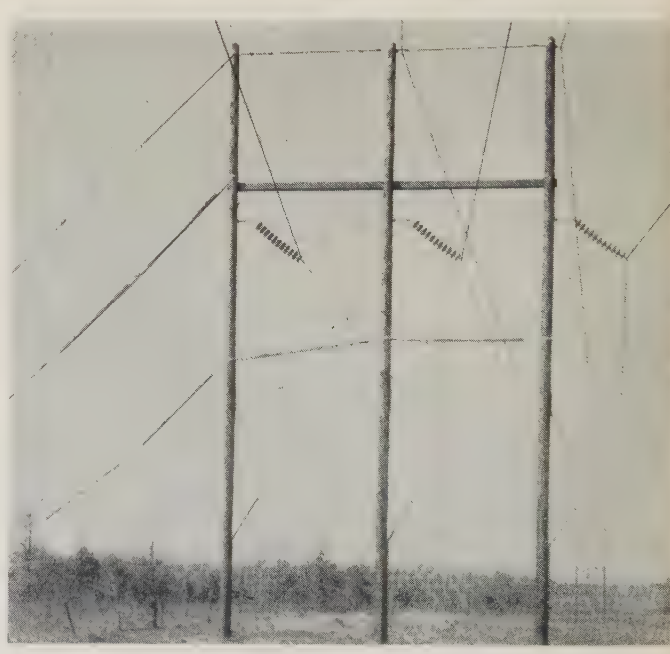

Fig. 10. Angle structure on a 132-kv line with lightning diverting cables grounded by a guy

The cables in this illustration have been partially retouched

data during the past few years. Summarized briefly, the conclusions are as follows:

1. High lightning insulation in itself, such as is practicable by utilizing wooden guy insulators, poles, and crossarms, is not effective in materially reducing the number of lightning flashovers occurring on transmission lines.

2. The 3 general types of design for lines to minimize lightning influence, which at present seem most adaptable and in which the lightning insulation strength of wood can be employed to advantage, are:

a. The simple design in which no particular attempt is made to avoid lightning flashover. However, the line construction features and its relaying and switching should be such as to minimize damage to insulators, conductors, and structures, thus giving practical assurance of the ability of the line to return immediately to service.

b. Diversion of lightning strokes from the power conductors without permitting insulator flashover. For successful operation, this type of design as now conceived requires liberal physical dimensions and insulations as well as favorable grounding conditions, which in general make it more applicable to the higher voltages. More complete data concerning the characteristics of lightning and the constants of the conducting circuits, as well as the development of technique for handling the problems involved, are required in order to place this method of design on better engineering and economic bases.

c. Drainage of lightning strokes through dynamic follow current interrupting devices. This method gives promise of proving applicable and advantageous for many situations, particularly in the lower voltage ranges, also where conditions both physical and economic are not favorable for the diversion design. Its success, of course, is quite dependent upon the development and limitations of the arc interrupting devices.

3. Impulse sparkover curves presented in the earlier paper[1] can be used with reasonable confidence in estimating the comparative insulation strengths of wood, insulators, combinations of insulators and wood, and air gaps.

4. Caution must be observed to avoid wood burning from leakage currents, particularly where insulator contamination may occur; in many instances such conditions may make it impracticable to utilize wood as insulation.

The cooperative and coordinated application of laboratory test and operating experience data; the systematic collection and careful analysis of line performance data; conclusions drawn therefrom; permission to review the newer resulting developments; and the material supplied specifically for this paper by the engineers who are cooperating in this practical attack upon the lightning problem, all have been very valuable in the preparation of this article. Companies that cooperated in supplying data include Arkansas Power & Light, Kansas Gas & Electric, Texas Power & Light, Carolina Power & Light, Tennessee Public Service, Pennsylvania Power & Light, Texas Electric Service, and Louisiana Power & Light companies, and Compania Nacional de Electricidad, Mexico. In many instances the experience data from individual systems would merit separate treatment and it is regretted that only a composite summary could be presented in this article.

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3. Realizing on the Insulation Value of Wood Construction, J. A. Jones, *Elec. Wld.*, Aug. 29, 1931, p. 37.

4. Diverting Direct Strokes, A. E. Silver, *Elec. Wld.*, Aug. 16, 1930, p. 313.

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Abstracts

Of Papers to Be Presented at the Winter Convention

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the technical sessions of the winter convention of the American Institute of Electrical Engineers (January 23–27, 1933) are published herewith, excepting only those papers published in this issue of Electrical Engineering. Abstracts of the remainder of winter convention papers are scheduled for publication in the February issue. In addition to the papers, 4 addresses are scheduled for presentation at the technical sessions.

Members vitally interested and wishing to obtain a pamphlet copy of any paper available in that form may do so by writing to the A.I.E.E. Order Dept., 33 West 39th Street, New York, N. Y., stating title, author, and publication number of each paper desired. In response to popular demand and within its space limitations Electrical Engineering subsequently may publish certain of these papers, or technical articles based upon them.

The Principle of Condenser Discharge Applied to Central Station Control Problems

By F. H. Gulliksen[2]

APPLICATION of a resistor connected in series with a condenser as a means for indicating the rate of change of a d-c potential is described in this paper. When the potential is varied the condenser will charge or discharge through the resistor, and the charging current will produce a voltage drop across the resistor. This voltage drop is approximately proportional to the rate of change of the applied potential.

A possible application of the condenser discharge circuit in connection with an electronic type impulse relay for quick response excitation regulators is discussed. The desirable features of the electronic type impulse relay compared with the conventional electromechanical devices for obtaining the quick response excitation feature are outlined; and it is pointed out why, under certain circumstances, the electronic equipment will give improved operation.

1. Texas Power and Light Company, Dallas, Texas.
2. Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

The principle of operation of an electronic voltage regulator is referred to, and an oscillogram is given indicating the definite antihunting action which can be obtained by means of the condenser discharge circuit.

A thermionic type automatic synchronizer which requires only 5 va per potential transformer is described in detail. The paper treats the method by which, for any frequency difference within limits of present operating practice, the synchronizer will cause the closing coil of the circuit breaker to be energized in advance of synchronism by a time equal to that required to close the breaker, so that, assuming the frequency difference between the 2 systems remains constant during the short time required to close the breaker, the breaker contacts will always be closed at the instant of zero voltage phase displacement.

A formula has been derived whereby the synchronizer "advance" may be calculated for various frequency differences when the constants of the thermionic circuits are known, and the results obtained with the thermionic type automatic synchronizer in a generating station with propeller type water wheels are described. **(A.I.E.E. paper No. 33-30)**

Pipe Line Pumping and Automatic Control

By John Fies[1]

(See p. 29–34, this issue)

Improved Power Supply Betters Street Railway Service

By J. A. Noertker[3]

(See p. 22–28, this issue)

Principles of the Direct Selection System of Supervisory Control

By M. E. Reagan[2]

SUPERVISORY control schemes of various types have been used for a number of years in controlling the operation of circuit breakers and similar equipment at a distant unattended substation. Supervisory control permits the selection of a large number of operations with only a few line wires.

"Direct selection" is the term applied to a system of supervisory control introduced in 1932. Its outstanding characteristic is high speed, since it selects any one of a number of remote units without requiring sequence stepping or counting chains. The "code" and the "synchronous" types of selection introduced by the same company in 1921 and 1924, respectively, both employed stepping means which in effect connect the line wires to other units in counting up to the one to be operated.

The direct selection system has been developed to control more than 50 units over 4 line wires, or 25 units over 2 line wires. With the 4-wire system, positive or negative potentials are applied to each of the wires. Two valve type receiving relays, based upon the copper oxide rectifier valve principle, are connected to each line wire to differentiate between positive and negative potentials. The placing of different combinations of positive and negative potentials at the sending end thereby permits the selection of various groups of the 8 receiving relays which in turn select the circuit breaker to be operated. Impulses to "close" or "trip" particular circuit breakers then are transmitted.

The 2-wire direct selection system utilizes full and half-wave pulsating battery voltages in addition to the straight direct voltage as utilized in the 4-wire arrangement. With both 2-wire and 4-wire systems, indication at the sending station of the operation of equipment at the remote station is given and all of the auxiliary features of previous supervisory systems such as telemetering, remote synchronizing, and position control are retained. The "antipumping" feature is likewise preserved. **(A.I.E.E. paper No. 33-31)**

A High Frequency Arc Welding Generator

By G. A. Johnstone[5]

(See p. 14–16, this issue)

High Velocity Vapor Stream in the Vacuum Arc

By R. C. Mason[2]

BLASTS of vapor have been discovered in the last few years to issue at high velocity from the cathode region of a vacuum arc. The consideration of this subject is important in the study of the arc. Previous theories of the cathode of an arc which have not taken account of the vapor stream must be extended, for the vapor blast, as it now appears, is a part of the cathode phenomena and as such must be included in any satisfactory theory of the cathode of an arc. The energy carried away in the high velocity vapor stream, which is not an inconsiderable part of the total energy loss at the cathode, must be included in the heat balance at the cathode. This paper reviews the experimental evidence for the existence of the vapor blast, and discusses the theories proposed to explain its origin.

The velocities were determined from: (1) force on the cathode and loss weight by the cathode; (2) force on a vane in front of the cathode, and mass of cathode material deposited on the vane; and (3) energy imparted to the vane, the mass of material deposited. Methods (1), (2), and (3) on the copper arc gave vapor velocities from 1 to 2.5×10^6 cm/sec, while method (1) on a mercury arc gave an average of 2.2×10^6 cm/sec. Sources of error would not change these values greatly.

Several proposed theories are shown to be inadequate; the one possible theory (Risch and Lüdi) is based upon the presence of multiply charged ions which leave the cathode with a high velocity after neutralization. **(A.I.E.E. paper No. 33-20)**

Communication Requirements of Railroads

By J. L. Niesse[6] R. C. Thayer[7]

(See p. 11–14, this issue)

Communication System on the Pennsylvania Railroad

By I. C. Forshee[8]

COMMUNICATION services required for operation of the Pennsylvania Railroad and for the convenience of its patrons are described in this paper, including a description of the company-owned outside plant required to provide these services, as well as

3. Cincinnati Street Railway Company, Cincinnati, Ohio.

4. Lehigh University, Bethlehem, Pa.
5. Great Lakes Electric Manufacturing Company, Chicago, Ill.
6. New York Central Lines, Detroit, Mich.
7. Great Northern Railroad, St. Paul, Minn.
8. Pennsylvania Railroad, Philadelphia, Pa.

tabulations showing the magnitude of some classes of business handled and plant involved. The Pennsylvania Railroad owns, maintains, and operates its pole lines, conduit lines, and cable system, and where wires or cables of commercial telegraph or telephone companies are on the railroad right-of-way, they are on a rental basis.

Among the services which must be rendered by the communication facilities described are train operation, related telephone messages, and supplementary telegraph and printer service; other facilities are described such as emergency service, time service, private branch exchanges, train information and Pullman reservation service. The equipment necessary to provide these communication channels is described briefly. **(A.I.E.E. paper No. 33-10)**

Railroad Signaling and Train Control

By
R. B. Amsden[9]
W. M. Vandersluis[9]

EFFICIENCY of train operation depends largely upon a system of directing train movements that will insure the maximum utilization of track and equipment capacity and the maximum output of train miles in a unit of time. In the earlier days the time interval method of railway signaling was favored, movements being directed by timetables and train orders. The space interval method is now universally recognized as most satisfactory, train movements being directed by block signals in addition to timetables and train orders. Block signals may be operated manually or automatically by means of a track circuit, the shunting of which by the trains operating upon the rails actuates the apparatus.

To guard against the failure of employees to observe, understand, or obey signal indications, means have been devised for automatically applying the brakes to stop or control the speed of a train without intervention of the engineman, when the track conditions require. At railway junctions, grade crossings, and movable bridges, it is necessary to interlock switches, derails, and bridge locking devices with the signals to prevent the setting up of conflicting routes and the clearing of opposing signals at the same time.

A more recent development is the system known as centralized traffic control in which the operation of all the switches and signals of an entire district or division is controlled directly from the dispatcher's office, and the operator, by means of colored light indicators, visualizes all train movements under his direction.

The scope of railway signaling is not confined entirely to the art of regulating and controlling railway traffic. In recent years the signal field has been enlarged to include the protection of roadway traffic at highway grade crossings and the application of car retarder systems at freight classification yards. Abundant experience in every application of the developments of the art of railway signaling has shown substantial economic advantages, an increase in safety, a reduction in train delays, an increase in ton miles per train hour, and a decrease in total ton-mile cost. **(A.I.E.E. paper No. 33-8)**

Modern Signaling on the Reading Railroad

By
E. W. Reich[11]
G. I. Wright[11]

MOST modern signal systems have many features of interlocking and signal control that are common to each other. A description of the signal system on one railroad, therefore, may be of interest to others. Following a brief outline of the earliest forms of signaling employed on the Reading Railroad, this paper describes the Reading's most recent installation of 100-cycle a-c color light signaling. The 100-cycle frequency was first used in the continuous coded train control territory, where a distinctive frequency was required to eliminate any possibility of foreign inductive interference, and was later adopted for use in electrified territory, as the range between the 100-cycle signal frequency and the 25-cycle electrification frequency permitted the use of frequency selective track relays.

The main features of the Reading's loop and code systems of continuous automatic train control and those of the automatic signaling and power interlocking are described. **(A.I.E.E. paper No. 33-21)**

Centralized Traffic Control and Train Control of the B. & O. Railroad

By
J. H. Davis[12]
G. H. Dryden[12]

CENTRALIZED traffic control systems concentrate at one point under the direction of one operator the control of train movements over a long section of track, and expedite the movement of traffic in that section. This is accomplished by bringing within view of the operator, indications as to the location of trains and the position of all switches and controlled signals, and also by bringing within his reach means whereby he is enabled to change, when safe to do so, the position of switches and signals affecting the movement of trains.

A centralized traffic control system incorporates practically all of the devices and appliances ordinarily installed in a low voltage interlocking system, and a complete single track automatic block system. This control system has been applied to 2 major sections of single track on the Baltimore and Ohio Railroad. The results of the experiences obtained may be summarized as follows:

1. The systems operate as intended.
2. Train delays incident to the opening and closing of passing siding switches and stopping or slowing down for train orders have been largely eliminated.
3. Expenditures for operating labor, overtime, and fuel have been reduced.
4. Track capacity is greater due to the closer spacing maintained between following trains, and safety of operation has been increased.

In this paper the operation of an intermittent inductive automanual train stop system on the Baltimore and Ohio Railroad also is discussed, this installation of automatic train control being between Baltimore and Philadelphia, Pa., a distance of 92.5 miles. The system is superimposed upon the automatic block signal system. The locomotive and wayside equipment which stops the train automatically when the necessity for such operation exists is described. **(A.I.E.E. paper No. 33-9)**

Low Frequency Self-Exciting Commutator Generator

By
J. I. Hull[13]

SELF-EXCITING a-c commutator generators have for some time been considered as sources of electrical power. However, what is probably the first commercial use of this type of generator as the prime source of energy for a power machine has recently been made. It is a 6-pole 1,200-rpm 3-phase machine rated 40 kva, 235 volts, 2.5 cycles, and is driven by a squirrel cage induction motor. The set supplies power to one or more 200 hp super-calender induction motors in order to secure threading operation at very low stable speeds. The generator is compounded for approximately flat voltage and frequency. Commutation has been found to be excellent and the voltage wave form is satisfactory.

The tendency of various forms of a-c commutating apparatus to self-excite is discussed in this article, and means for converting this ordinarily objectionable quality into a desirable characteristic are outlined. Low frequency applications are shown to be the most attractive for the commutator generator and a number of such applications are pointed out. The theory of self-excitation in a completely neutralized machine, a machine having plain excitation, and one with compound excitation for constant voltage and frequency are

9. Illinois Central Railroad, Chicago, Ill.
10. Cleveland Union Terminals Company, Cleveland, Ohio.
11. Reading Company, Philadelphia, Pa.
12. Baltimore and Ohio Railroad, Baltimore, Md.
13. General Electric Company, West Lynn, Mass.

considered as well as a machine having compound excitation for falling voltage and frequency. Advantages of voltage and frequency control for reversal of induction motors are discussed. (A.I.E.E. paper No. 33-34)

3. For isochronism, i. e., when the natural frequencies coincide, then damping is necessary in both the governor and the generators, and in larger amounts than for either conditions 1 or 2. **(A.I.E.E. paper No. 33-7)**

Some Factors Affecting Temperature Rise in Armatures of Electrical Machines

By C. J. Fechheimer[14]

TREATMENT is given in this paper to the temperature rise in the armatures of electrical machines after the machines have been run for such lengths of time that the temperatures have ceased to rise. However, it is stated that the method given for calculating these temperatures for the steady state condition can be extended so as to apply to the transient state as well.

The method consists of calculating the temperatures when a machine is operated at full voltage, no load, and calculating separately the temperatures when the machine is operated under short circuit with full load current. In the first case, the iron losses will of course be greater, and in the second case the copper losses will be greater. An electrical analogy is drawn to the flow of heat through the armature under these 2 conditions, and it is shown that by superimposing the calculated heat flow for these 2 conditions, results are obtained which satisfactorily give the resulting temperatures. Coefficients for use in the formulas given may be determined by test.

Values calculated by this method are compared with those obtained by the usual tests, and close agreement is shown. It is stated also that the method is useful for the testing of large machines for which it is costly to make full load tests. Two relatively inexpensive tests are made, one at no load at normal voltage, and the other on short circuit at full load current. **(A.I.E.E. paper No. 33-14)**

Parallel Operation of A-C Generators—Action of Governors and Damper Windings

By M. Stone[2]

SATISFACTORY parallel operation of a-c generators is dependent primarily upon the proper load-speed characteristics of the generators. When driven by reciprocating type prime movers it has been thoroughly investigated and recognized that none of the major torque harmonics of the prime mover should coincide with any of the natural periods of oscillation of the several generators operating in parallel. This paper describes an investigation of the further question of stability of parallel operation when load is suddenly thrown off or on the system, troubles of this sort having been experiences in actual operation.

The analysis of the situation shows that a governor-controlled prime mover driving synchronous generators operating in parallel constitutes a coupled oscillatory system of an unusual nature. The coupling is such that under certain relations of the natural periods of the 2 oscillatory systems, and for restricted values of governor friction and damper winding resistance, a finite initial disturbance such as a load shock will result in load pulsations of increasing amplitude.

This condition of stability can be influenced in several ways, and is determined as follows:

1. When the governor natural frequency is higher than the generator natural frequency, then stability is preserved by having sufficient damping in the governor system, and is of no consequence when introduced in a damper winding.
2. When the governor natural frequency is less than the generator natural frequency, then an effective damper winding will retain stability, while damping introduced into the governor will be of little use.

14. Consulting Engineer, Milwaukee, Wis.

Synchronous-Motor Pulling-Into-Step Phenomena

By H. E. Edgerton[15] G. S. Brown[15] K. J. Germeshausen[15] R. W. Hamilton[15]

INVESTIGATIONS of synchronous motor phenomena during transient conditions have been made, using a mechanical calculating machine called the "differential analyzer" to solve the non-linear differential equations involved. Previous investigations have been made on a preliminary calculating machine called the "product integraph." The extent and accuracy of the solutions, however, were limited on this preliminary machine, and the work was confined principally to determining whether or not a synchronous motor would synchronize for the worst switching conditions. The curves presented in the present paper and obtained by use of the differential analyzer make it possible to calculate quantitatively the additional load that may be synchronized if the field switch is closed at the most favorable switching angle.

The method of obtaining solutions is given for a cylindrical rotor or synchronous induction motor, and for a salient pole synchronous motor. A typical case of a round-rotor motor is considered in the paper, to illustrate the method of solution.

The advantages which are found to result from angularly controlled field switching may be summarized as follows:

1. From 0 to 45 per cent more load can by synchronized with switching controlled to approximately the most favorable angle compared to that for the ultimate case.
2. A given motor and load can be pulled into step from a larger slip.
3. When the field is switched at the most favorable angle the slip during the transient never exceeds its initial steady state value.
4. Favorable switching minimizes the mechanical and electrical surges. **(A.I.E.E. paper No. 33-26)**

Two-Reaction Theory of Synchronous Machines—Part II

By R. H. Park[16]

RESULTS of certain mathematical investigations which have been found to be of practical use in the analysis of problems involving the transient behavior of interconnected machines are presented in this paper.

The first result given is a formula for damping torque during continuous oscillation. The magnitude of the damping torque which obtains during such oscillations is principally of interest in connection with studies of the tendency of certain types of synchronous machines to hunt at light load. This tendency, which is particularly marked in the case of machines which always operate at negligible mechanical load, such as synchronous condensers and converters, has long been appreciated and it has been recognized that the tendency toward hunting is increased if the machine in question is supplied with power over a line of relatively high resistance, and that it may be reduced or eliminated by equipping the machine with an amortisseur winding.

There have been several mathematical analyses of this phenomena in which the amortisseur, which in reality consists of a number of parallel circuits, has been represented by only 2 circuits, one located symmetrically with respect to the magnetic axis of the poles, and the other located symmetrically with respect to the interpolar space. In addition certain simplifying assumptions usually have been made in the process of analysis itself, which do not appear to have been fully justified. The present paper extends the analysis to include commercial types of amortisseurs, and also avoids the questionable simplifying assumptions referred to.

15. Massachusetts Institute of Technology, Cambridge, Mass.
16. Calco Chemical Company, Bound Brook, N. J.

The second result developed is a demonstration of the fact that little error may be anticipated if the formula derived for damping torque during continuous oscillations is used in the computation of the damping torque obtaining during transient oscillations, such as those which come under consideration in the study of system stability.

The third result given is a simple formula for the roots of the cubic equation which determine the wave shape of current and torque on 3-phase short circuit, or when synchronizing out of phase.

The fourth and last result is a description of an equivalent circuit which has been found useful in calculating the decrement of the short circuit current of interconnected machines. **(A.I.E.E. paper No. 33-22)**

Application of Air Conditioning to Railroad Passenger Cars

By
W. C. Goodwin[2]
Charles Kerr, Jr.[2]

APPLICATION of air conditioning to passenger cars has required development of considerable equipment, including axle generators of larger capacity, a suitable generator drive, a light weight compressor for operation with Freon, and a system which would stand the severe service met in railway operation. The exacting requirements of weight and space added greatly to the difficulty.

For weather conditions, the temperature within the car to be cooled should never be more than 15 deg F above the outside air; the effect upon a person entering or leaving would otherwise be too severe. When the outdoor temperature exceeds 95 deg F the car cooling equipment should have a capacity sufficient to keep the car at 82 deg F, and to hold the humidity at 60 per cent or lower.

Experience has shown that for the average car, a cooling equipment of 6-ton capacity is needed, requiring for power a total of about 12 hp. To handle this load in addition to the car lighting and battery charging requires a 15-kw generator. The development of a 15-kw generator and drive within the limited space on a car truck involved many difficulties. Two new types of drive were used experimentally, one involving a gear drive and the other a V-belt. Special equipment was designed to insure that the generator had the same polarity irrespective of direction of rotation, and to give satisfactory voltage regulation.

In the cooling equipment for railway service, the following are essential requirements:

1. Complete refrigerating assembly in one unit.
2. Direct expansion of the refrigerant in the air stream cooler without the use of intermediate heat exchanger.
3. The equipment must meet the clearance requirements of the railroads.
4. No floor space should be required to install.

A high speed direct driven compressor with forced feed lubricating system, low inertia type of valves, and a positive crankshaft seal was developed. To provide precooling while standing in railway terminals, a 32-volt d-c compressor motor is provided in addition to a 220/440 volt, 60-cycle, 3-phase, a-c motor. As a result of these developments reliable and efficient apparatus now is available which has proved its practicability in actual service. **(A.I.E.E. paper No. 33M1)**

Power Supply for Main Line Railway Contact System

By
P. A. McGee[11]
E. L. Harder[2]

THE GENERAL system problem encountered in the supply of power for electric traction is dealt with through a study of the electrical characteristics of the principal available systems, namely:

600-volt d-c third rail;	12–24–36 kv, 25 cycle, 3-wire
1,500-volt d-c catenary;	24–48–72 kv, 25 cycle, 3-wire
3,000-volt d-c catenary;	12–66 kv, 25 cycle, 2-wire
	12–132 kv, 25 cycle, 2-wire

In the first part index figures are developed for specifying concisely the characteristics considered. Thus the trolley systems are described in terms of permissible amperes and ampere-miles as limited by heating and regulation, respectively, while charts are given connecting these quantities with dimensions of train movements. Kva-miles is the index used for transmission. For example, a single phase 132-kv circuit using 4/0 conductors can transmit 3.7 million kva-miles with reasonable regulation. That is, it can transmit 37,000 kva for 100 miles or half that amount for twice the distance. Heating limits must, of course, be taken into account.

The specification of railway load in terms of dimensions of fleets of trains of equal size, speed, and spacing makes possible the general charts for determining regulation and heating limits and substation loads which are given in the paper.

A study of power system requirements for specific light, medium, and heavy traffic conditions gives a perspective of the electrical requirements with each type of system considered. It shows that heating of the contact system generally limits the substation spacing with suburban loads except for the 600-volt d-c third-rail system, while regulation is the limiting factor with main line freight and passenger traffic. One-hr substation loads from 200 to 2,000 kw per single track mile are indicated for suburban service and 90 to 600 kw per single track mile for combined freight and passenger loads. A tabulation is presented giving the essential electrical characteristics of the principal existing electrifications. This tabulation indicates that existing loads come within the range of the general study given in the paper.

Among the specific deductions drawn are the following:

1. There is little advantage from the substation capacity standpoint in spacing substation farther apart than trains.
2. In main line service, where train spacings are considerably greater than the required substation spacings with low voltage systems, the required substation capacity is considerably less with the higher voltage contact lines.
3. The load factor on generating stations 100 miles apart is 1.5 to 2.5 times that for substations at 10-mile spacing, ratios which are indicative of the total capacity required in transforming or converting apparatus to feed a railway at these relative spacings. **(A.I.E.E. paper No. 33-12)**

Operation of 3,000-Volt Locomotives on the Cleveland Union Terminals Electrification

By
F. H. Craton[17]
H. W. Pinkerton[10]

OPERATION of the 3,000-volt d-c passenger locomotives on the Cleveland Union Terminals electrification has been studied after an initial period of service of more than 2 years. Twenty-two locomotives weighing 210 tons each are in service, normally handling passenger trains weighing 1,275 tons trailing over grades as high as 1.56 per cent.

During the 2 years over 1,000,000 miles of operation has been recorded, divided between about 410,000 miles per year for passenger service and 90,000 miles for switching. These figures indicate that the average performance in switching service is about 2 miles per hour, whereas the customary method of accounting credits switching locomotives with 6 miles per hour.

An analysis of the average time used for inspection and repairs shows an availability of 92 per cent. For the same period the utilization factor of 54 per cent is observed. The utilization factor will doubtless be improved with a resumption of normal traffic.

Data is given on energy consumption, both in road and switching service, and curves are plotted showing the variation in energy consumption with different train weights. The all-day average in coach-yard switching is found to be about 85 kwhr per hr per locomotive, including auxiliaries, or a net average of about 55 kwhr per hr. Interesting records of brush wear, data on replacement of hub liners, wear on pantograph strips and condition of commutator and motor bearings are produced.

The record of failures for the 2-year period of operation shows 12 engine delays of 3 or more minutes. Six of these were classed as electrical failures, giving 170,000 locomotive miles per failure. There were no failures due to mechanical causes or hot bearings in journals, traction motors, or auxiliaries.

17. General Electric Company, Erie, Pa.

In addition to the energy consumption curves speed-time-current curves are given for the Twentieth Century Limited, a profile of the line, main and auxiliary circuits for the locomotive, and characteristic curves. (**A.I.E.E. paper No. 33-36**)

Calculation of Single Phase Series Motor Control Characteristics

By H. G. Moore[17] C. J. Axtell[17]

CALCULATION of the characteristics of a-c equipments as applied to locomotives and cars presents difficulties not found when dealing with d-c equipments due to the additional variables involved. Characteristics of the motors are usually presented on the basis of constant voltages at the motor terminals. However, the motors operate in service from an assumed constant voltage power source with a certain amount of impedance such as transformer, preventive coil, and bus bar or cable resistance and reactance in series with the motors. Not only does the vector relation of the impedance drop to the motor voltage vary with motor power factor, but the impedance itself varies depending upon the combination of contactors and transformer taps being used.

Trial and error methods formerly have been used, wherein the various factors were estimated and then adjusted until all conditions were satisfied. This paper describes a simple method of plotting acceleration curves by resolving the reactance and resistance of the transformer, reactive coil, and wiring into a single effective reactance and effective resistance for each open circuit transformer secondary voltage. By the use of these factors and the motor characteristics simple calculations can be made to determine with any given motor voltage and load the required open-circuit voltage of the transformer. Any errors introduced by the use of the approximate values of effective reactance and resistance are of very minor value and do not appreciably effect the final results. (**A.I.E.E. paper No. 33-15**)

Simplified Speed Control for Single Phase Locomotives

By W. A. Giger[18]

A GREAT number of locomotives have up to this time been equipped with control systems utilizing either electro-pneumatically or electromagnetically operated unit switches and preventive coils in various combinations. However, a great many single phase locomotives built abroad have been equipped with a simple and quite efficient control system, whereby a tapping switch and bridging resistances are used. With such a tapping switch the number of current breaking switch units is greatly reduced. The weight of the entire control system, which does not utilize any preventive coils, is also less than that of unit switch-preventive coil systems.

Based upon the experience with the tapping switch control system, which so far has been employed mainly on the low voltage side of the locomotive transformer where normally the currents are quite heavy, a new control system has been developed which greatly simplifies the arrangement of apparatus within the cab of a single phase locomotive. With this system, all the switching necessary to regulate the output of a locomotive is done on the high voltage side of the transformer; the current to be handled is so small that the weight and particularly the space required for the tap changer is reduced greatly when compared with any other single phase locomotive control system heretofore employed. Two double-unit single-phase express locomotives having one-hr ratings of 7,500 and 8,800 hp, respectively, both built and put in operation about one yr ago, are equipped with this high tension switchgear. The operation of these locomotives so far has been very successful and the high voltage tap changers have operated with the same reliability as the low voltage tap changers which are utilized on several hundred single phase locomotives. It is believed that this high tension control system enables the designers of single phase locomotives to simplify the arrangement of electrical apparatus within the cab considerably, and it is furthermore expected that it will result in considerably lower maintenance cost than that of any other control systems used up to this time. (**A.I.E.E. paper No. 33-11**)

18. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Report on Impulse Testing of Commercial Transformers

By F. J. Vogel[19] V. M. Montsinger[20]

(See p. 9–11, this issue)

A Recent Development in High Current Mercury Arc Rectifiers

By E. H. Reid[21] C. C. Herskind[21]

A SINGLE unit mercury arc rectifier of 3,000-kw rating at 600 volts is discussed as regards design and operation. A typical installation, that of the new Eighth Avenue subway of the New York board of transportation, is described where units of this size have been advantageously applied to the subsurface substations.

An important characteristic of the rectifier unit is its operating temperature which is materially higher than heretofore used in general practice. Tests show that up to a certain temperature the arc drop is reduced as the temperature is raised. This indicates that the maximum efficiency is obtained by operating at the temperature giving the lowest arc drop. Among other advantages of a high operating temperature is the increased cooling efficiency.

The rectifier is of the grid controlled mercury vapor type with insulated grids surrounding the anodes. In addition to straight rectification, it is hoped that it will find many applications in the future where control by grid controlled electronic valves is desired. (**A.I.E.E. paper No. 33-13**)

Synchronous-Mechanical Rectifier-Inverter

By S. S. Seyfert[4]

THE OBJECT of the development described in this paper has been to so modify and equip the synchronous commutator of the short-circuiting type as to enable it to perform the 2 functions of rectification and inversion interchangeably under conditions of comparatively high voltage and current.

The successful application of a synchronous commutator to the rectification and inversion of large values of power involves the meeting of several very exacting requirements. The simple short-circuit type of synchronous-mechanical rectifier has been shown to meet these quirements when properly designed and equipped with certain auxiliary apparatus which modifies the a-c supply voltage.

The synchronously-driven rotor consists of $n + 1$ insulating disks for an n-phase system, each carrying a conducting segment. These segments act in sequence to so interconnect the stationary brushes where terminate the several a-c phases and the d-c lines, that the phases are short-circuited, commutated, and re-inserted in the series d-c circuit in the proper order.

To insure good commutation and prevent sparking, 2 components of the third harmonic are introduced into the voltage of each a-c phase. The harmonic voltages may be produced by a synchronously-driven single-phase booster alternator connected into the neutral line of the primary transformer supply. This alternator has 2 fields in quadrature.

19. Westinghouse Electric and Manufacturing Company, Sharon, Pa.
20. General Electric Company, Pittsfield, Mass.
21. General Electric Company, Schenectady, N. Y.

Oscillographic records show that the experimental rectifier embodying the features outlined passes from full load rectifying to full load inverting in response to a sudden change of d-c system voltage with perfect commutation in every cycle during the transient.

A partial or total loss of a-c excitation results in no distress to the rectifier. The apparatus delivers 3-phase power, 3-phase excitation, or both, to an unexcited a-c system with a performance quite similar to that accompanying its normal function. Currents resulting from d-c short circuit can be commutated if sufficient voltage capacity is provided in the commutating harmonic machine.

The motor-generator set supplying the harmonic voltages has a nominal kva rating of about 20 per cent of that of the system and circulates less than 2 per cent of the power. The apparatus appears easily applicable to ordinary a-c to d-c or d-c to a-c conversions including double conversions resulting in change of frequency and offers promising possibilities toward the solution of the problem of d-c power transmission. **(A.I.E.E. paper No. 33-40)**

Protection of Rotating A-C Machines Against Traveling Wave Voltages

By W. J. Rudge, Jr.[20] R. W. Wieseman[21] W. W. Lewis[21]

PROTECTION of rotating a-c machines against traveling wave voltages divides itself into 2 problems: protection of insulation to ground against impulse overvoltages and protection of the turn insulation against steep wave fronts. The impulse insulation strength of the machine to ground is assumed equal to approximately 2 times the terminal-to-terminal crest voltage ($2.12E$). The turn insulation strength is given in curve form and varies with machine kva and speed.

The protective scheme includes arresters 2,000 ft and 500 ft out on the line, or other means to limit the incoming voltage to 2.5 times the arrester rating, a special arrester at the generator terminal to hold the voltage to $2.12E$ and a capacitor at the generator terminal to modify the shape of the wave to limit the turn-to-turn stresses. For grounded neutral 0.1 μf is sufficient; while for isolated neutral, capacitance up to 0.5 μf may be necessary. Ground wires over the line for 2,000 ft are recommended to protect against direct strokes.

For cases where the machine feeds the outgoing line through transformers an arrester is recommended at the high voltage side of the transformer, and at the machine terminals a special arrester is recommended in multiple with a capacitor, which in most cases may be 0.1 μf. **(A.I.E.E. paper No. 33-32)**

Recommendations for Impulse Voltage Testing

An A.I.E.E Subcommittee Report[23]

(See p. 17–22, this issue)

Lightning Investigation on Transmission Lines—III

By W. W. Lewis[21] C. M. Foust[21]

RESULTS of a lightning investigation conducted in cooperation with a number of power companies are presented in this paper which is the fourth of a series of A.I.E.E. papers by the same authors. The principal work in the past 2 years, summarized in this paper, has been a study of the magnitude and polarity of tower current caused by lightning strokes. The data indicate that when the product of the tower current times the tower footing resistance is high, flashover of the line insulator may be expected, and conversely when the product is low flashover usually does not occur.

A portion of one of the lines was covered with overhead ground wires and the remainder of the line had no overhead ground wires. Those strokes which were accompanied by trip-out occurred largely in the section without overhead ground wires, although the number of strokes in each section was roughly proportional to its length. To be effective, however, the ground wires must be supplemented by low tower footing resistance. The buried ground cable or counterpoise has proved valuable in reducing tower footing ground resistance.

The data indicate that line trip-outs occur with high negative currents almost exclusively. Negative currents mean that the tower top is negative with respect to ground, i. e., that the cloud is negative with respect to the earth and tower. Positive cloud-to-ground strokes, while occurring frequently, appear to be relatively harmless. Polarity characteristics of the cloud and of flashover between dissimilar electrodes are quite important in understanding the mechanism of direct strokes.

Tentative line insulation and tower footing resistance specifications to render steel tower lines with overhead ground wires practically immune from flashover may be written: for example, on 66-kv lines, 8 insulator disks and not more than 6 ohms resistance; on 132-kv lines, 12 disks and 8 ohms; and on 220-kv lines, 20 disks and 12 ohms. Lines coming within these specifications have operated successfully without flashover in sections exposed to lightning. **(A.I.E.E. paper No. 33-42)**

Operating Experience With Wood Utilized as Lightning Insulation

By H. L. Melvin[25]

(See p. 36–41, this issue)

Lightning Experience on 132-Kv Transmission Lines of the American Gas and Electric Company System

By Philip Sporn[23]

CONTINUING a 4-year operating record of an extensive 132-kv transmission system under lightning conditions, this paper presents and discusses the record for 1930 and 1931. Operating experience is given on yearly line outages due to lightning, severity, and frequency of lightning storms over the system, frequency of double circuit outages, extent of line and station apparatus damage, effect of tower footing resistance in reducing lightning outages, reduction in tower footing resistances by the use of driven ground rods and counterpoises, effect on lightning outages by overinsulation, relative magnitudes of single-phase, 2-phase, and 3-phase line faults, and location of lightning flashovers on the line in reference to top, middle, and bottom conductors.

Following is a summary of the conclusions drawn:

1. Reasonably good protection against lightning is afforded station apparatus by the use of lightning arresters and grading insulation at the substation.
2. Grading shield protection on the line itself has proved very effective.
3. Transmission line outages are materially reduced by reduction of tower footing resistance.
4. In case of 2-circuit lines the percentage of outages where both lines trip increases as the generating capacity of the system is increased.
5. No evidence of direct hits to the line wires themselves between towers has been shown.
6. Increasing line insulation considerably on lines of low operating voltage (132-kv insulation for 33-kv, 44-kv, and 66-kv lines) has not been sufficient to prevent follow-up current and consequent line outage in case of lightning flashover.

23. American Gas and Electric Company, New York, N. Y.

24. Public Service Electric and Gas Company, Newark, N. J.

25. Electric Bond and Share Company, New York, N. Y.

7. Lightning flashovers on the line causing power follow-up result in single-phase faults in approximately 73.8 per cent, 2-phase faults in 19.6 per cent, and 3-phase faults in 6.6 per cent of the cases.

8. The only line using 2 overhead ground wires directly above the transmission circuits has shown an excellent performance even though the average tower footing resistance of the line was 12 ohms.

9. The large number of lightning outages on wood pole lines operated at 132 kv seems to indicate that the degree of lightning protection assumed to be possible with the use of wood or lightning insulation has not been obtained in this case. (A.I.E.E. paper No. 33-43)

parts of regulating equipment for completely automatic process control. Two proposed regulating schemes are discussed. The first employs a photoelectric tube in a "balanced bridge" circuit. The second employs a single photoelectric tube with a rotating apertured diaphragm in a "nul" circuit. Both schemes are identical beyond the photoelectric tube circuit and employ a definite and adjustable amount of correction together with a definite and adjustable amount of inoperative time after each correction has been made. (A.I.E.E. paper No. 33-45)

Impulse and Dynamic Flashover Studies of 26-Kv Wood Pole Transmission Construction

By
A. S. Brookes[24]
R. N. Southgate[24]
E. R. Whitehead[2]

IN THIS paper is presented the results of laboratory tests with a 1,000,000-volt surge generator and 60-cycle high voltage testing equipment on 26-kv transmission poles now in use on a large system. Actual impulse curves are given for several types of straight span pole top construction. Values of impulse flashovers for the basic component parts of a pole are presented to furnish means for comparing types of construction not tested and to aid in applying protective gaps for the prevention of wood shattering. Wooden crossarm braces greatly increase the insulation on double-circuit vertical configuration construction but are of little use on single-circuit horizontal configuration pole tops. The data given enable the more complete utilization of the wood on pole tops for insulation.

An analysis of the factors governing the development of a power arc following impulse sparkover and corresponding experimental data showing the extent of occurrence of such arcs in air and through wood are presented. The following conclusions are drawn:

1. Wood is an effective insulator for lightning voltages and should be utilized fully in transmission line design when increased impulse insulation is desired.

2. The net flashover voltages (one electrode grounded) of wood and porcelain combinations of simple pole tops can be estimated from the data presented within 20 per cent.

3. Seasoned wood has high 60-cycle insulating value for short times of voltage application when dry, but its insulation value is much impaired with even a slight increase in moisture content. Creosoting has no appreciable effect on these properties.

4. Creosoting or moisture have no appreciable effect on the impulse sparkover values for wood.

5. Measurements of 60-cycle arcovers on wood pole tops cannot be used as an accurate indication of the impulse sparkover voltages.

6. Tests indicate that the occurrence of the dynamic arc following sparkover cannot be eliminated by increased clearances within practical design limits for the operating voltages under consideration.

7. The fact that the dynamic arc was prevented from following the path of an impulse arc when confined within wood fibers offers interesting possibilities for field experiments.

8. Damage to pole tops by wood splintering can be prevented by application of suitable gaps having a breakdown voltage less than that shown to be required to sparkover the insulator and wood.

9. Data are now available for designing a wood pole line with almost any practical degree of lightning reliability by increased insulation or the use of protective devices. (A.I.E.E. paper No. 33-44)

Light Sensitive Industrial Process Control

By
J. V. Alfriend, Jr.[2]

CONTROL of hydrogen ion concentration in metal flotation, electrolytic reduction, and electrolytic refining processes has usually been accomplished by the expensive, slow, and inaccurate methods of colorimetric analysis and manual control. The desirability of automatic regulation of the concentration of these chemicals has been apparent for a long time but no method of regulation has been suggested that meets all the requirements.

The success of light and color sensitive devices in sorting and matching of colors has indicated that these devices could be used as

A Standard of Low Power Factor

By
W. B. Kouwenhoven[26]
L. J. Berberich[26]

NEED of a suitable standard of low power factor for use in checking the accuracy of the various devices and bridges employed in the measurement of loss in dielectric samples is pointed out in this paper. The relative merits of the different methods that have been proposed for this purpose are discussed and then the low power factor standard which has been developed is described. This standard consists of a shielded and guarded air capacitor having in series with its guard and main circuits an ideally shielded resistor. The ideally shielded resistor is made up of 2 concentric resistances with the same value of resistance per unit length. The inner resistance is connected in series with the main electrode of the air capacitor, and the outer resistance, which shields the inner, is connected in series with the air capacitor guard. The use of this ideally shielded resistor in connection with the air capacitor makes it possible to have a zero potential difference at all points between the guard and the main electrode.

The power factor of a circuit of this type can be calculated accurately as the units that make it up may be measured separately and their respective values determined. The low power factor standard constructed has a capacitance of approximately 500 $\mu\mu f$ and is provided with 3 ideally shielded resistors, giving a power factor range of 0.000195 to 0.00199. The air capacitor is hermetically sealed in a tank and can be used, when compressed air forms the dielectric, at potentials as high as 25 or 30 kv.

The paper also presents the results obtained where the low power factor standard was used to check the accuracy of several bridges. The low power factor standard satisfactorily represents a dielectric specimen. The capacitance used is loss free and independent of variations in frequency. The power factor and loss of the standard with the ideally shielded resistance in series can be computed accurately. It also possesses the primary requisite of a standard, namely, permanence. It is available for use. (A.I.E.E. paper No. 33-5)

A Bridge for Precision Power Factor Measurements on Small Oil Samples

By
J. C. Balsbaugh[15]
P. H. Moon[15]

A BRIDGE constructed at the Massachusetts Institute of Technology for the measurement of the power factor of small oil samples to an absolute power-factor precision of 10^{-6} is described in this paper. The bridge is being used in a research project for the study of commercial cable oils and pure synthetic hydrocarbons.

The bridge is of the Schering type but due to the small size of the sample and the desired power factor precision unusual refinements in the design were necessary. It is a symmetrical bridge with equal ratio arms and contains variable high voltage condensers for capacitance balancing. The use of these condensers prevents shunt capacitances to ground in the resistances of the power factor measuring arms from affecting the power factor measurements and makes it necessary to determine only differences in absolute capacitances of

26. The Johns Hopkins University, Baltimore, Md.

the power factor measuring condensers for different settings. The bridge is designed for a maximum voltage of 5,000 volts.

The detecting circuit consists of 5 stages of amplification, a double-shielded input transformer, filter, a-c galvanometer, and a vibration galvanometer. The bridge is normally operated at 55 cycles per sec and the filter eliminates interference from other electrical machinery operating in the building and also eliminates the effect of harmonics. This circuit will give a power factor sensitivity of approximately 4×10^{-8} with a bridge voltage of 1,000 volts and a frequency of 55 cycles per sec.

In the past it generally has been considered that the losses are negligible in air condensers. Measurements show that the power factor of air condensers may be of the order of 10^{-6} and in some cases as high as 10^{-4}. The loss appears to be a surface phenomenon instead of occurring in the body of the gas and depends upon the area of the plates, voltage gradient, nature of the surface, and kind of metal used for the surfaces. Since any power factor measuring bridge measures the difference in absolute power factor of the high voltage condensers in the bridge, obviously measuring to a given power factor precision requires the evaluation of the absolute power factor of these condensers to the same power factor precision. A method has been developed which will permit evaluation of these absolute power factors and this has been done for the condensers and test cells used in this bridge.

The accuracy of the shield balance also is discussed and it is shown that for high-precision power-factor measurements it is in general desirable to provide for both magnitude and phase balancing of the shield. With a single shield, as used in this bridge, the accuracy of the shield balance is determined primarily by the difference in the capacitances between bridge and shield on the 2 sides of the bridge. It is suggested for high-precision power-factor bridges that variable condensers be installed between bridge and shield on the 2 sides of the bridge for equalizing these capacitances. When phase balancing of the shield circuit is provided, insulation of relatively high power factor between bridge and shield circuits will not have any effect on the power factor measured by the bridge. This insulation should be effectively shielded from the high voltage sections.

An oil cell has been developed for this research which will permit complete evacuation, give clean and gas-free metallic surfaces and eliminate any losses in the glass container from being measured with the oil. **(A.I.E.E. paper No. 33-35)**

Skin Effect in Rectangular Conductors

By H. C. Forbes[27] L. J. Gorman[27]

IN THE DESIGN of bus bars for generating stations and substations, particularly of the isolated-phase type, there is need for more complete information on the skin effect, at commercial frequencies, in large conductors of rectangular cross-section. The present paper describes a method of measurement and presents data that were obtained for conductors of various ratios of width to thickness.

It can be shown that the ratio of a-c to d-c resistance of a conductor may be determined as a function of the parameter, $P = \sqrt{\frac{8\pi f A}{\rho}}$, where

f = frequency in cycles per sec
A = area of cross-section in sq cm
ρ = specific resistivity in abohms per cu cm

This relationship suggested the possibility of making tests at high frequencies on conductors of relatively small cross-section, and applying the results to obtain the skin effect in large conductors at lower frequencies. This scheme of testing offers great advantages because of the difficulties in making a-c measurements at very low voltages where large size conductors are to be tested at commercial frequencies. In this investigation, the above principle was applied to tests on small rectangular conductors of 0.003 to 0.01 sq in. cross-section, having various ratios of width to thickness, and tested at frequencies ranging from 22 to 287 kc.

A test method was developed by which the a-c resistance of the rectangular conductors was determined by comparison with equivalent round conductors of approximately the same cross-section the a-c to d-c resistance ratios for the round conductors were calculated from published data on the skin effect in round wire. The high frequency test current was supplied by a vacuum tube oscillator coupled to a secondary circuit in which the test bars were connected. The data obtained at the high frequencies were reduced to commercial frequencies and the results are presented in the form of curves from which the a-c to d-c resistance ratios at 25 and 60 cycles can be determined readily for rectangular conductors of various sizes having the ratios of width to thickness covered in the tests. **(A.I.E.E. paper No. 33-2)**

27. New York Edison Company, New York, N. Y.

Variable Voltage Oil Well Drilling Equipment

By A. H. Albrecht[30]

VARIABLE voltage d-c drive is stated to be the most recent advance in electric oil well drilling equipment and has been used successfully by both the cable tool and the rotary method of drilling. A discussion of the methods of drilling is given in this paper in order to show the characteristics required of the electrical equipment.

In a typical installation the power plant consists of 2 d-c generators with direct connected exciters. These generators may be driven by an a-c motor taking energy from the usual power supply, or they may be driven by steam or internal combustion engines, the latter being most frequently used. An investigation was carried on to determine the combinations of various types of motor and generator windings best suited for rotary drilling. These combinations included differentially wound generators designed for series or parallel connection supplying energy to a shunt wound drilling motor, and differential and shunt generators designed for series connection supplying energy to a compound drilling motor. The variable voltage system of control is used with each of these combinations.

Among the factors considered in this study were suitability of operation, relative first cost and operating charges, relative installation costs, relative safety, choice of size of equipment, and choice of electrical characteristics. It is shown that the particular conditions at a given installation must determine the combination of generators and motors to be used. **(A.I.E.E. paper No. 33-29)**

Recent Developments in Electronic Devices for Industrial Control

By F. H. Gulliksen[2]

THE GENERAL characteristic of electronic control devices is outlined in this paper, and the features which make the application of these devices desirable from an industrial point of view are referred to. Also, various recent developments in electronic devices for industrial control are described in detail.

An electronic type time delay relay with a time delay range up to 3 min is referred to. Electronic equipment for the control of register in cutter applications is discussed, and diagrams and photographs of the control equipment designed for reflected light applications for paper speeds up to 500 ft per min are shown.

The principle of operation of an electronic type voltage and speed regulator for d-c machines is given, and oscillograms are shown which indicate the extremely quick response characteristic of this electronic regulator. Electronic starting equipment for control of d-c motors operated from an a-c source is shown. With this equipment the a-c voltage is rectified by means of power glow tubes and is applied to the armature of the d-c motor. By means of phase shift control of the glow tube grid voltage, the voltage applied to the motor armature may be controlled smoothly from zero to maximum.

Miscellaneous photoelectric control applications in the industrial field are outlined in an attempt to show the adaptability of photoelectric control equipment to various industries. **(A.I.E.E. paper No. 33-24)**

30. Standard Oil Company of California, LaHabra, Calif.

The Use of Communication Facilities in Transmission Line Relaying

By J. H. Neher[31]

LARGE size and complexity of the modern power system are directing the attention of relay engineers to the problem of securing overall protection for the major transmission lines. The advantages of this type of protection, inherently instantaneous for faults within its boundaries and inherently selective in the case of faults on other parts of the system are readily apparent.

Overall protection of transmission lines may be accomplished by comparing the relative instantaneous directions of residual current or the relative directions of fault current flow at the terminals of the line by means of a communication system which is arranged to trip both ends of the line when the relation obtained indicates that the line is faulted. This arrangement using a communication system as the auxiliary link between the line terminals has marked advantages over the conventional differential system of overall protection requiring the use of a-c pilot wires.

In cases where the transmission line is provided with a conventional form of distance or balance current protection, instantaneous tripping of both ends of the line can be secured for faults at all locations on the line by the addition of a communication system arranged to trip the circuit breakers at both ends of the line simultaneously whenever either breaker receives a tripping impulse from its associated relay system.

The communication system required for either of these protective schemes is essentially a telegraph system and may comprise a carrier current equipment using the transmission line itself as the connecting medium or else may consist of a simple d-c telegraph, low-frequency rectified a-c pulse telegraph, or voice frequency telegraph employing conventional telegraph or telephone circuits.

The proper selection and coordination of the relay communication system with respect to the telephonic communication, telemetering, or supervisory control systems employed as adjuncts to the power system will result in a minimum of additional communication facilities being required for relaying. **(A.I.E.E. paper No. 33-3)**

Protection of Electrical Apparatus —Recommended Relay Practice

An A.I.E.E. Subcommittee Report[32]

(See Electrical Engineering for December 1932, p. 829–34)

A Sequence Relay for Network Protectors

By H. S. Orcutt[33] M. A. Bostwick[34]

USELESS operations of protectors on low voltage distribution networks are practically eliminated when controlled by a relay that has been designed in accordance with the principles laid down in the companion paper "Application of Phase Sequence Principles to Relaying of Low Voltage Secondary Networks." This relay consists of a single phase induction disk directional element, 2 overcurrent control elements of the contactor type, and suitable current and voltage filters to make it operative on 3-phase circuits. All parts, with the exception of 2 resistors and a phasing lamp, are mounted in a standard relay case.

The directional element, which has a sensitive watt characteristic, is energized through positive phase sequence current and voltage filters. Its operation, when the protector is closed, is controlled by the current elements which are built into the positive and negative phase sequence branches of the current filter. The positive phase sequence current element prevents balanced current reversals from exceeding chosen magnitudes and assures relay operation on balanced 3-phase faults. The negative phase sequence element is set to pick-up on relatively small magnitudes of current and serves to initiate operation of the directional element when it is desired to deenergize the feeder by switching operations at the power station. Both elements operate to energize the directional element during fault conditions.

A short time delay is obtained between the closure of the current element contacts and the directional element trip contacts. Needless tripping of the protector by sudden application of secondary loads at times when reverse current is being supplied through the protector is thus avoided.

The directional element also performs phasing functions to close the protector when satisfactory voltage conditions exist on the feeder. The phasing circuit consists of 2 separate coils of high impedance which are connected across the breaker contacts in phases *B* and *C*. A saturating reactor and capacitor, near resonance, are used in series with the phase *B* coil, while a tapped reactor and phasing lamp are used in the phase *C* circuit. When cross phase conditions resulting from faulty cable connections are encountered, the impedances of these circuits increase and phase angles change to prevent closing the protector.

The sensitive-insensitive tripping characteristic and phasing features included supply the present need of a relay that will permit balanced power flow in either direction through the protector and yet provide a means of deenergizing the feeder to which it is connected without employing load back methods that may cause system disturbances. All of these functions are controlled by the single relay, without auxiliaries. **(A.I.E.E. paper No. 33-17)**

Phase Sequence Relaying

By H. R. Searing[27,33] R. E. Powers[2]

AN IMPROVED network relaying system utilizing a conventional single-phase relaying element and plunger type overcurrent elements excited by symmetrical phase sequence components to represent completely power flow conditions and control protector operation on a 3-phase 4-wire secondary network system is described in this paper. The general features of relay design and operating experience are outlined in the companion paper "A Sequence Relay for Network Protectors."

The relaying system outlined is capable of controlling protective performance under normal operations to prevent unnecessary protector opening due to inherent power reversals of minor magnitude, such as 30 to 100 per cent. Further, discriminating features are possessed which insure tripping functions under abnormal primary circuit conditions. The relaying system will function for any type of primary fault, but will not permit protector opening on any type of secondary load or fault.

Selective tripping of the protector units is secured, after the feeder supply breaker is opening intentionally at times of inspection, etc., by providing a source of negative phase sequence voltage to circulate negative phase sequence current in the feeder circuit. This may be accomplished by the use of a small motor generator set or inductive loading between phases at the generating source. The tripping function may be initiated in delta connected circuits by earthing one conductor after the station circuit breaker is opened.

The relaying system employed is fundamentally as rugged and reliable as the existing standard apparatus and has the advantage of simplification, as a single element single disk relay and filters perform all function of the present 3-element watt relay plus a single phase phasing relay. The combination of 2 sensitive devices produces a selective combination that permits balanced reverse energy of any predetermined value to flow through the protector, but initiates a tripping impulse upon the combination of reverse magnetizing watts and negative phase sequence current on the order of 5 to 10 per cent of the protector ampere rating. Tripping functions are initiated at times of balanced 3-phase primary faults by the combination of reverse energy equivalent to magnetizing watts in combination with positive phase sequence overcurrent.

Field tests extending over the past 2 years verify fundamental analysis and subsequent relay design. **(A.I.E.E. paper No. 33-16)**

31. Philadelphia Electric Company, Philadelphia, Pa.
32. General Electric Company, Philadelphia, Pa.
33. United Electric Light and Power Company, New York, N. Y.
34. Westinghouse Electric and Manufacturing Company, Newark, N. J.

Higher Steam Pressures and Temperatures—A Challenge to Engineers

By
M. D. Engle[36]
I. E. Moultrop[36]

(See p. 3–9, this issue)

Empirical Equations for the Magnetization Curve

By
J. P. Barton[38]

AN EQUATION of the form $\mu = PB^a$ has been derived experimentally, where μ represents permeability and B represents flux density. This equation closely reproduces the flux density-permeability curve for magnetic materials of various compositions and qualities in the flux range of approximately 80 to 6,500 gausses. The data, obtained in the usual way from averaging samples, is graphed on log-log paper using μ/B^2 versus B, the latter being the independent variable. The coefficient P and exponent a are determined by graphical and analytical means, both being influenced by the nature of the material, the former being indicative of the relative value of the initial permeability. Several curves and data sheets show the salient features of the method and accuracy in reproduction. A list of various grades of silicon steel and alloys is included to illustrate the values P and a may have, and the range over which the equation holds.

An extension of this method to other portions of the magnetization curve indicates 4 regions which can be stated by similar equations. One region terminates in initial permeability, one lies between maximum permeability and approaching initial permeability (the region mentioned above), another lies between maximum permeability and saturation, while the fourth includes saturation, its equation being of an indeterminate form. A chart is given listing the average values of P and a for the 4 regions, for 4 per cent silicon sheet steel. Comparisons are made with several other expressions for the magnetization curve as derived by other writers. Theoretical consideration of the entire curve as given by μ/B^2 versus B on log-log paper, indicates 4 distinct phases of magnetization coupled by 3 transitional phases. Each of the 4 phases follows closely the general equation $\mu = PB^a$, with P and a having different values.

The degree of accuracy in obtaining these empirical equations is sufficient for most commercial design purposes to allow their use in calculation over the flux densities for which they hold, without reference to the B-H curve. The data plotted as $0/B^2$ versus B for the entire range of the magnetization curve is useful for certain design procedures where it is desirable to obtain B for various values of μ/B^2, which frequently appears in certain methods of design. **(A.I.E.E. paper No. 33-27)**

Tensor Analysis of Rotating Machinery

By
Gabriel Kron[39]

IN ANALYZING the transient or steady state performance of any rotating machine a system of linear equations is set up for finding the currents, another system is set up for the torque, etc. The setting up of the equations is usually laborious and due to the accidental steps made in their solutions the final results are in a form that is difficult to interpret physically. A method is shown by which the procedure of setting up the systems of equations and finding and interpreting the results are standardized in a few simple forms that can be quickly and easily handled by routine substitutions of constants.

A general rotating machine is assumed to consist of a stator with asymmetrical, and a rotor with symmetrical, magnetic structure, each having several layers of windings with all brushes, slip-rings, and connections removed. The instantaneous sinusoidal current-density wave, also the flux density and voltage waves, are assumed to form a multi-dimensional space vector with components along the direct and quadrature axes. The transient impedance that transforms the n-dimensional current vector into the terminal voltage vector is represented by a tensor of a rank 2 (dyadic) consisting of all the design constants arranged in a square array (matrix). The transient impedance of a particular machine is found from the iron tensor by a transformation of coordinates. That is, the usual connection diagram is represented by another rectangular array (copper tensor) showing the new coordinates along the brushes and slip-rings, the series connections between windings, etc. The resulting transient impedance is the scaler product of 3 vectors, namely, the copper tensor, the iron tensor, and the conjugate of the copper tensor.

With speed as a parameter the currents along the coordinate axes are found from the equation, terminal voltage equals current times impedance, by the routine calculation of the inverse of a dyadic. The terminal voltage components may be any functions of time: d-c, a-c, Heaviside unit functions, etc. In the sudden short circuits of all machines (except where the slip-rings are connected to unbalanced loads) the instantaneous currents are found with the aid of the expansion theorem and Duhamel's integral just as in any linear stationary network. In the steady state analysis of a-c machines all calculations with complex numbers are eliminated by doubling the number of dimensions. An important relation is that the impedance (transient or steady state) of a set of interconnected machines is the sum of the impedance of each individual member.

It is shown in this paper that the iron tensor and all transient impedances can be divided into 3 component impedances. Accordingly an equation of voltage can be written which shows that a rotating machine differs from a stationary network by an instantaneous voltage generated by cutting the resultant multidimensional rotor flux wave. Equations of power and torque also are given which open up a new field for the visual representation of machine performance with the aid of quadric surfaces.

During acceleration the performance is known to be represented by an equation of motion which is a tensor representation of the equation of motion of Lagrange for a system containing only kinetic energy and dissipation.

During hunting the transient state is represented by an equation which shows the additional transient voltages and torques. **(Paper for informal presentation only.)**

The Dielectric Losses in Impregnated Paper

By
J. B. Whitehead[26]

IN THE experiments described in this and in earlier papers, a method has been found whereby it is possible to predict accurately the dielectric loss and other properties of impregnated paper, in terms of simple electrical properties, as measured under continuous potential, of the oil and of the paper separately. Moreover, the methods developed permit the separation of the dielectric loss into 2 components, one due to conduction, and another due to reversible dielectric absorption, thereby throwing much new light upon the nature of the dielectric loss, and upon the relation of its 2 components to the basic properties of the oil and the paper.

An essential feature of the experimental work is the use of the amplifier-oscillograph for the taking of charge and discharge curves under continuous potential over time intervals comparable with the period of the alternating cycle. In general the currents for these short time intervals, in oil, in paper, and in impregnated paper are decreasing functions of the time, and have markedly different values to those pertaining to longer time intervals. Usually the oils are characterized by an initial conductivity which is constant over a period of about one sec, and this constant conductivity exactly accounts for the dielectric loss in the oil at 60 cycles. It is evident in these cases that dielectric loss is a frictional phenomenon caused by the back and forth oscillation in the electric field, of the ions contained in the oil. Dry paper shows a typical decaying charging current curve, and an identical discharge curve, indicating dielectric absorption and negligible conductivity. Curves of this character

36. Edison Electric Illuminating Company of Boston, Mass.
38. Milwaukee, Wis.
39. United Research Corporation, Long Island City, N. Y.

persist no matter to what stage of dryness the paper is carried. Similar charge and discharge curves are found for the impregnated paper, except in this case the ordinates of the charge curve are uniformly greater than those of the discharge curve, the difference giving the magnitude of the leakage due to conduction. In all of these cases the loss under alternating stress may be accurately computed from the short time oscillographic curves taken under continuous potential, as shown by comparison with loss measurements with the Schering bridge.

Ten different oils representing a wide range of viscosity and electrical conductivity have been studied. It was found that for any one oil the product of the initial short time constant conductivity and the viscosity was approximately constant over the temperature range 30 deg to 60 deg C. This product is proportional to the number of free ions in the oil and is proposed as a measure of the "electrical purity" of the oil.

The dielectric constant of the dry paper, of the oil, and of the impregnated paper were measured in each case over the temperature range of 30 to 60 deg. Analysis of the results shows that the dielectric constant of the impregnated paper is due to a direct volumetric combination of the oil and paper, and that the dielectric constant of impregnated paper may be computed on the simple assumption of a 2-layer dielectric. The dielectric constant of the wood cellulose fiber studied was found to have the value 5.55 at 45 deg, increasing slightly with temperature.

The dielectric loss in impregnated paper is generally greater than the sum of the losses in equal volumes in oil and paper separately. The increase is due to reversible dielectric absorption in the Maxwell sense, although for reasons already indicated, a quantitative agreement with the theory is not to be expected. However, an outstanding result of the present work is experimental proof that the losses in the impregnated paper have definite relations with the basic loss in dry paper, and with the initial conductivity, and the index of the electrical purity of the oil described above. Moreover, the nature of these relations is indicated. Thus it is shown that over the whole range of oils and of temperature studied, there is a conduction component of the dielectric loss in the impregnated paper which is directly proportional to the initial constant conductivity of the oil. This is a natural result in general accord with ionic theory, but is here shown for the first time. The component of the loss in impregnated paper due to reversible dielectric absorption is by far the more important component. It is shown that the increase of this quantity in impregnated paper, over that in the paper alone, is a simple function of the "electrical purity" of the oil as represented by the product of its initial conductivity and its viscosity. This new relationship has been found to be very uniform over the wide ranges of viscosity and conductivity represented by the 10 different oils and the temperature variation of each. It demands further study, but the present indication is that it should be an important aid both in research and in practice.

The results of this paper indicate that if the methods here developed should be applied to other types of insulating papers for the determination of their constants, it should be possible to write a general expression for the predetermination of the total loss, the power factor, and the dielectric constant, resulting from the impregnation of any type of paper with any type of oil in terms of the separate properties of each; in other words, to place the design of impregnated paper insulation as regards dielectric loss on an accurate engineering basis. **(A.I.E.E. paper No. 33-4)**

Harmonic Commutation for Thyratron Inverters and Rectifiers

By C. H. Willis[21,40]

RECTIFIERS and inverters employing grid-controlled gas or vapor filled electronic valves require some means of interrupting the current through the tube. Commutation is the term applied to the interrupting of this current. In this paper the problem of commutation is discussed and a method of using a harmonic circuit of reduced kva to force commutation is described.

By the aid of harmonic commutation, inverters can be operated to supply lagging loads, and rectifiers can be phase controlled in the leading quadrant. A rectifier which is phase controlled 90 deg leading becomes equivalent to a synchronous condenser and may be used for power factor correction.

A duplex type of circuit is described which enables a polyphase inverter to produce sinusoidal voltage and current, and permits a rectifier to draw a sinusoidal current from the a-c system.

The inverter is shown to differ from a rotary converter only in that the sum of the a-c and d-c armature reactions of the inverter must always be zero. By providing 2 sets of tubes in the inverter, one on the unity power factor axis and the other on the zero power factor axis, a crossed axis inverter is developed which will furnish sinusoidal current and voltage for all conditions of load. **(A.I.E.E. paper No. 33-18)**

40. Princeton University, Princeton, N. J.

A New Method for Initiating the Cathode of an Arc

By J. Slepian[2]
L. R. Ludwig[2]

AFTER presenting various theories of the cathode of an electric arc and describing numerous methods for initiating an arc cathode, a new method of starting the arc cathode is described. It is of the separating contact type, but to a considerable degree is free from the inertia difficulty of ordinary separating contacts. One form of this starter consists of a small section pointed tungsten rod placed in a mercury arc tube so that it dipped slightly to a depth of about one mm below the mercury surface. On sending sufficient current through the rod, the cathode of an arc was promptly started at the rod and mercury junction, and this starting could be regularly repeated 60 times per sec.

Further investigation of this starter disclosed that a rod of relatively high resistivity partly immersed in mercury had very extraordinary properties with respect to the initiation of arc cathodes on the mercury surface, and the starting of the arc was extremely regular and reliable. A gradient of 100 volts per cm along the starter rod appears to be necessary. The starter is insensitive to the degree of immersion in the mercury.

It is stated that the starting of the arc to the main anode of various types of gas filled tubes may be effected and controlled entirely by the new starter, thus eliminating the permanent arc cathode and control by the grid. **(A.I.E.E. paper No. 33-23)**

Capacitance and Loss Variations With Frequency and Temperature in Composite Insulation

By H. H. Race[21]

VARIATIONS in electrical properties of composite insulation with changes in temperature and frequency are important because they lead to concepts of physical causes of such variations, and therefore indicate how to obtain improved electrical properties in commercial materials. Typical experimental data are presented showing the capacitance and loss characteristics of synthetic resin laminated materials and of imperfect composite dielectrics made from combinations of fused quartz or glass and semi-conducting liquids. An example is given showing agreement between calculated and observed characteristics of such a glass-liquid combination.

Theoretical analyses are given, showing that the general form of the capacitance and loss characteristics could be caused by any one of several physical mechanisms.

As a result of these studies it seems probable that in synthetic resin laminated products semi-conducting materials in small insulated pockets or fibers can account for observed characteristics and can be represented mathematically by the Maxwell-Wagner theory. It is also shown that capacitance and loss measurements at one frequency and temperature cannot generally be used to predict corresponding values under different conditions. **(A.I.E.E. paper No. 33-46)**

News

Of Institute and Related Activities

14 Technical Sessions Included on Carefully Planned Winter Convention Program

ARRANGEMENTS have been practically completed for the A.I.E.E. winter convention which will be held with headquarters in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 23–27, 1933. Contrary to the general trend of the times toward reductions, the program offers all the splendid features of past winter convention programs, but at a reduced cost to those in attendance. The schedule of events consists of 14 technical sessions which present a broad field of timely subject matter. Interesting and profitable inspection trips will provide recreation. A buffet dinner and a dinner dance afford ample opportunity for social discourse and in addition there will be special entertainment for the visiting women.

Technical Program

Detailed information concerning the technical program was published on p. 873–4 of Electrical Engineering for December 1932. In the program on those pages may be found many names of authors well known in the electrical industry, as well as others who also are making valuable contributions to existing theory and practice. Additional information and a change of title are outlined in the following paragraphs.

Two addresses have been added to session I, on electrochemistry and electrometallurgy. One is by George W. Vinal, Bureau of Standards, Washington, D. C., on "Resistance of Storage Battery Separators and the Resistivity and Viscosity of Battery Electrolytes." The other is by P. H. Brace, Westinghouse Elec. & Mfg. Co., and Sydney Rolle, U.S. Metals Refining Co., on "High Conductivity Oxygen-Free Copper." Printed copies of these addresses will not be available.

The first paper listed in session B, electric welding, should be entitled "New Studies of the Arc Discharge." The author is J. Leland Myer, Engineering Foundation Fellow from Lehigh University.

Edison Medal Presentation

The Edison Medal awarded to Bancroft Gherardi "for his contributions to the art of telephone engineering and the development of electrical communication" will be presented to him in the Engineering Auditorium on the evening of Wednesday, January 25. Details of the award are published in the "Personal" columns of this issue.

Entertainment and Social Events

A smoker with buffet dinner and a variety of entertainment features will be held on Tuesday evening, January 24. This occasion always provides a good opportunity to chat with friends and meet the friends of others.

The dinner dance will be held in the ballroom of the Hotel Roosevelt, Thursday evening, January 26. Music will be rendered by a well known orchestra. Many members recall this delightful social event in former years and they are anticipating its annual occurrence.

For the women a luncheon and bridge will take place at the Engineering Woman's Club on Tuesday afternoon, January 24. Arrangements have been made by the women's committee, with Mrs. E. B. Meyer, as chairman. During the convention information for the women will be available at headquarters as to theaters, shopping districts, and similar information.

Reunion Dinner for Columbia Electrical Engineers

The dinner will be held on Wednesday, January 25, 6:30 p.m. at the Columbia University Club, 4 West 43rd Street. Dean J. W. Barker will speak and the dinner will conclude in time to permit attendance at the Edison Medal presentation in the Engineering Societies Building. Price for the dinner is \$1.50. Apply for reservations to A. D. Hinckley, Columbia University, New York, N. Y.

Register in Advance

Each member should register in advance by mail, thus permitting the committee to have badges ready. This will save time and prevent congestion at the registration desk on arrival. An advance registration return card was included in the mailed announcement.

Reservations for hotel accommodations should be made by writing directly to the hotel preferred.

Inspection Trips

The committee in charge of trips is desirous of rendering maximum service to members and their guests in connection with this feature of the entertainment program and asks that members make their wishes known early. The convention literature will make suggestions in this regard as an aid to the selection of those trips that will enable each to utilize available time most enjoyably and instructively. Advance information will contain a card, the return of which will aid the committee in anticipating the wishes of members.

The following trips are contemplated:

Scenic Trip up Hudson River

The beauties of the panoramic views of the Hudson River and the famous Palisades on the New Jersey side are yearly becoming better known and

A plane of Transcontinental and Western Air, Inc., in front of the terminal building at Newark, N. J., airport. Opportunity will be afforded for taking a flight over Newark Bay and lower New York. The round trip by de luxe buses and including the flight will not exceed \$3. The route to the airport will transverse the new \$21,000,000 overhead highway $4^1/_2$ miles long, and returning, will cross the new George Washington Bridge

more outstanding among such places where nature may be seen in both loveliness and grandeur. Last year this trip was much enjoyed by those who were not dissuaded from taking it because of rain in the forenoon. The trip will start from the Engineering Societies Building, cross the new George Washington Bridge, travel north up the Hudson River on the top of the Palisades to the Bear Mountain Bridge, cross the Bear Mountain Bridge and return to the starting point via the Scenic Approach Highway and the Bronx Parkway Extension. It may be possible to make a brief stop at the Millwood substation of the Westchester Lighting Company.

To Newark Airport—the Busiest in the World—and a Flight Over Newark Bay and Lower New York

Arrangements are being made for a visit to this eastern terminus of a huge transcontinental air transport system and which will afford opportunity not only for inspecting but riding as well in the planes used in transporting passengers from New York and Newark to Pittsburgh, Chicago, Kansas City, Los Angeles, and San Francisco.

Transcontinental & Western Air, Inc., will be our hosts, and members and their guests will be privileged to inspect the airport and hangars. It also is anticipated that visitors will be shown an actual demonstration of the ground-to-plane radio-telephone system developed for T. & W. A. by the Western Electric Company. The route to the airport will be via the new $21,000,000 overhead highway 4 1/2 miles long, which, starting at the New Jersey terminus of the Holland Tunnel, extends across the Jersey meadow land and affords a fine view of the area and its development.

New Jersey Industrial Area

For those who would enjoy a bus trip through the industrial area of New Jersey, with brief stops at points of specific interest, a trip is in contemplation and will be described more fully in the convention literature.

Other Points of Interest

Opportunity will be afforded to those who wish to visit the installations of the neighboring utilities, railroad electrifications completed or in progress, or industrial or other enterprises which may command the interest of the members and their guests. Inspection privilege to visit the following places of interest has been accorded:

The Delaware, Lackawanna and Western Railroad electrification

Roseland switching station of the Public Service Electric and Gas Company

160,000-kw tandem compound units of the Brooklyn Edison Company, and research laboratory

East River generating station of New York Edison Company

Hell Gate station, United Electric Light and Power; Load Ratio Control Equipment, units in operation for control of both voltage and phase angle

A-c calculating board of the Pennsylvania Railroad, located at Pennsylvania Station

New Eighth Avenue subway substation

Vertical distribution in new 70-story building, Radio City

Electrical Testing Laboratories

Electric Research Products, Inc.

Electrical Institute of the Electrical Association of New York, Inc.

New York Museum of Science and Industry, where may be seen the new permanent exhibits relating to power and electrical science and technology. These exhibits should prove of great interest to our members and their guests.

Schedule of Events

Monday morning and evening have been left open for committee meetings. Capital letters A, B, etc., denote technical sessions.

Monday, January 23

10:00 a.m.	Registration
2:00 p.m.	Opening of convention A—Automatic stations B—Electric welding

Tuesday, January 24

10:00 a.m.	C—Communication D—Rotating electrical machinery
1:00 p.m.	Women's luncheon and bridge
2:00 p.m.	E—Transportation
6:00 p.m.	Buffet dinner and smoker

Wednesday, January 25

10:00 a.m.	F—Education G—Insulation coordination
11:00 a.m.	Inspection trips
2:00 p.m.	Board of directors meeting
8:30 p.m.	Edison Medal presentation Lecture

Thursday, January 26

10:00 a.m.	H—Lightning I—Electrochemistry and electro-metallurgy
2:00 p.m.	J—Instruments and measurements K—Industrial applications

Friday, January 27

10:00 a.m.	L—Protective devices M—Selected subjects N—Research

Storm King Highway above Bear Mountain Bridge on the Hudson River, which will be included in an all-day scenic trip. The new George Washington Bridge, the Palisades of the Hudson, luncheon at the famous Bear Mountain Inn, and a visit to the West Point Military Academy are included in this trip which will be made by bus. The fare will not exceed $2.25 exclusive of luncheon

Secretary and Editor Are Appointed by Institute

Henry H. Henline, since January 1927, assistant national secretary and since June 1932, acting national secretary, has been appointed national secretary of the American Institute of Electrical Engineers, effective January 1, 1933. This action was taken December 6, 1932, by the Institute's executive committee which, by authority of the Institute's board of directors, met in place of the regular December meeting of the board. (The Institute's national secretary is appointed annually for the term of the administrative year August 1–July 31.) Mr. Henline will be fully responsible, under the president and the board of directors, for the general management of Institute affairs. As mentioned in the biographical sketch carried on p. 415–16 of Electrical Engineering for June 1932, Mr. Henline is an electrical engineering graduate from the University of Illinois (1914), a former member of the faculty at Stanford University, Calif. (1917–30), and for some years has been intimately and actively associated with Institute affairs.

G. Ross Henninger, since October 1, 1930, associate editor of the Institute, has been appointed editor, effective January 1, 1933, upon the retirement of George R. Metcalfe, Institute editor since February, 1910. Mr. Henninger will have responsible charge of the Institute's editorial staff and its technical publications, under the direction of the Institute's publication committee. A biographical sketch appears elsewhere in this issue.

Engineers Form Professional Development Council

Seven national engineering bodies have organized the Engineers' Council for Professional Development with the announced objective of advancing the professional status of the engineer. The participating bodies and their representatives are:

American Society of Civil Engineers—J. Vipond Davies, Harrison P. Eddy, C. F. Loweth.

American Institute of Mining and Metallurgical Engineers—Donald F. Irvin, D. H. McLaughlin, Benjamin F. Tillson.

American Society of Mechanical Engineers—C. F. Hirshfeld, J. H. Lawrence, W. E. Wickenden.

American Institute of Electrical Engineers—Charles F. Scott, C. O. Bickelhaupt, L. W. W. Morrow.

American Institute of Chemical Engineers—H. C. Parmelee, A. B. Newman, John M. Weiss.

Society for the Promotion of Engineering Education—Robert I. Rees, H. P. Hammond, Dugald C. Jackson.

National Council of State Boards of Engineering Examiners—D. B. Steinman, T. Keith Legare, P. H. Daggett.

This new agency plans to coordinate and promote efforts directed toward higher professional standards. Its immediate objective is stated to be the development of a system whereby the progress of the young engineer toward professional standing can, through the development of those qualifications that render the engineer a valuable member of Society, be recognized by the man himself, by the profession, and by the public. The organizers believe that this will involve increased development along social, economic, and generally cultural lines, as well as the maintenance of high technical standards of education and practice.

The Engineers' Council for Professional Development is embarking on a program of improving means for educational guidance of young men with respect to the engineering profession, the formulation of criteria for colleges of engineering, the determination of a program of personal and professional growth for young engineering graduates and the formulation of methods whereby engineers who have met suitable standards may receive corresponding professional recognition.

Four committees have been appointed to carry on this program:

Student Selection and Guidance, Harrison P. Eddy, consulting engineer, Boston, Mass., Chairman.

Engineering Schools, Dr. Karl T. Compton, president, Massachusetts Institute of Technology, Chairman.

Professional Training, Brig.-Gen. Robert I. Rees, assistant vice-president, American Telephone and Telegraph Company, Chairman.

Professional Recognition, Conrad N. Lauer, president Philadelphia Gas Works, Chairman.

A.I.E.E. Editor Retires After 23 Years' Devoted Service

GEORGE R. METCALFE, since February 1910, the active pilot of the editorial department of the American Institute of Electrical Engineers, retired from active service January 1, 1933, bringing to a close a long career of devoted service. Quiet, patient, and self-effacing, an untiring worker and a stickler for accuracy, Mr. Metcalfe during his more than 2 decades of service quietly has pioneered the way in many important developments in the Institute's publication practice and its publication service to its members. His infinite patience, his tact, and his perseverance enabled him to "ride out" many a storm in the earlier periods of the Institute's more active publication development, a time when—even more than now—technical writers and self-styled technical writers considered all editors to be unmitigated nuisances and proceeded to deal with them accordingly. Within the definite limitations of his office he has guarded jealously the interests of the membership and has achieved some noteworthy results in the field of technical publication.

Statistical data concerning Mr. Metcalfe and his long and active career are notably scarce as a result of his supreme modesty. Nevertheless by means of much effort and solicitation of friends, acquaintances, and former associates, some information has been gathered and will be outlined in the following paragraphs.

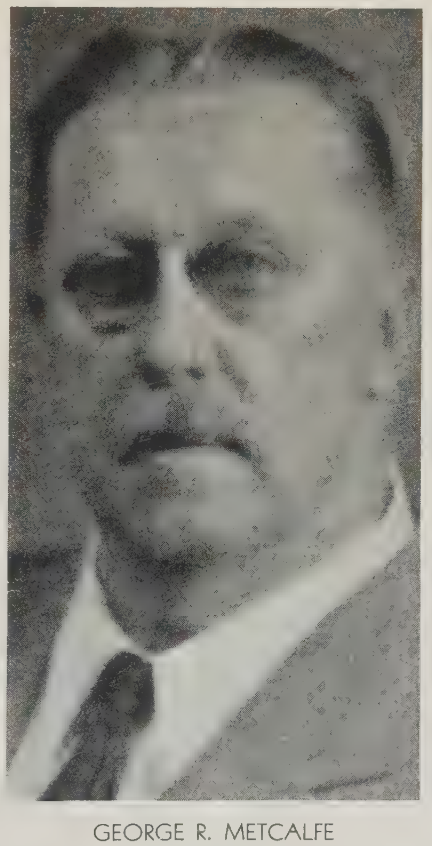
In Early Railway Work

George Richmond Metcalfe was born in Brooklyn, N. Y., February 4, 1865, to George and Elizabeth Talbot (Root) Metcalfe. He pursued normal educational efforts, attending Brooklyn Polytechnic Institute (1879–81) subsequently to enter Stevens Institute of Technology, Hoboken, N. J., to pursue the electrical engineering course as then offered in the mechanical engineering department, graduating with the class of 1886. Subsequent to graduation Mr. Metcalfe served for 6 months as assistant to the chief engineer of the Edison United Manufacturing Company (New York) after which he spent most of the year 1887 in the drafting and testing departments of the Daft Electric Company (New York) in connection with the design of controlling switches used on the Daft system of railway control apparatus. After that he was associated for about 8 months with J. C. Henry, designing and building railway motors installed by Henry for the Rochester Electric Street Railway Company, Rochester, N. Y.

Late in 1888 Mr. Metcalfe became associated with the (Frank J.) Sprague Electric Railway and Motor Company, which at that time was engaged in the historic electric street railway developments at Richmond, Va., and elsewhere. In his capacity as inspector and superintendent of construction, Mr. Metcalfe was intimately associated with the development of early Sprague electric railway lines at Steinway, and between Brooklyn and Jamaica, Long Island, N. Y. He was in responsible charge of important work in connection with the construction of the electric street railway lines and associated power plant for the Winnipeg (Manitoba) Electric Street Railway Company, reputedly the first electric street railway in Canada.

During 1890 and 1891 Mr. Metcalfe served as electrical engineer with the Edison General Electric Company. Commissioned inspector and superintendent of construction, he was in responsible charge of important work in connection with the building of the Brandon (Manitoba) Electric Light and Power station.

On July 1, 1891, Mr. Metcalfe became associated with the late C. O. Mailloux, who then was active as an independent consulting electrical engineer. Mr. Metcalfe calculated the windings, proportions, and other design features of the electric generators and motors built by Mr. Mailloux for the Metropolitan Railroad, Washington, D. C. His work also embraced extensive design and application in connection with the then radically new electrical installations at the Toledo, Ohio, and the Utica, N. Y., insane asylums, the Wagner Palace Car Company, Lang's Brewery at Buffalo, N. Y., and many other commercial and industrial plants.



GEORGE R. METCALFE

Became an Editor in 1892

Mr. Metcalfe's career turned into a new channel when, in May 1892, he became associate editor of *Electricity*, a popular electrical weekly first issued in Chicago, July 22, 1891, and subsequently moved to New York with the issue of December 16, 1891. The publication was "devoted to the advancement of electrical interests," and emphasized the "popular and practical as well as the technical and theoretical." With his technical training and wide practical experience, the understanding and interpretation of the tremendously rapid development of that promotional era in electrical history was a task well handled by Mr. Metcalfe, who became editor of the publication with the issue of June 29, 1892. From 1897 until 1899 he was a member of the New York firm of Metcalfe and Moeller, actively engaged in the maintenance and repair of electrical machinery, incandescent lamp fixtures, and associated electrical and mechanical equipment.

Again turning into the editorial channel, Mr. Metcalfe became technical editor of the *Street Railway Review*, published in Chicago, Ill., serving in that capacity from 1899 to 1904. Mr. Metcalfe's last reported activity in the field of strictly engineering application was his service during 1903 and 1904 as electrical engineer for the Woods Motor Vehicle Company. Following this, he became editor of the *Technical World*, also published in Chicago; during this same time (1904–5) he edited textbooks for the American School of Correspondence, Chicago.

On April 16, 1906, Mr. Metcalfe was called to Pittsburgh, Pa., by the Westinghouse Electric and Manufacturing Company, to become "editor of the publication department," a position of responsibility which he developed and filled with high credit until he severed his connection with the Westinghouse Company, December 1, 1909. Subsequent to that he became associated with the publication department of the General Electric Company at Schenectady, N. Y., where he remained until he came to A.I.E.E. headquarters in New York in February 1910, as Institute editor.

Edited I.R.E. Proceedings

In addition to the other activities mentioned, Mr. Metcalfe edited technical articles for the International Encyclopedia (1904–5) and during 1926–1927, edited the "Proceedings" of the Institute of Radio Engineers. At one time, Mr. Metcalfe was a member of the American Institute of Electrical Engineers, having been elected an Associate April 19, 1892, and transferred to full membership November 15, 1892, but subsequently resigned May 1, 1898. On November 8, 1899, Mr. Metcalfe married Grace Darling Brown; their children are: Richmond (deceased), Winthrop, Donald, George, and Grace Elizabeth. For many years the Metcalfe home was at Middletown, N. Y. (where Winthrop still resides), but more recently established at Hewlett, Long Island, N. Y., where his family now is situated.

Nominating Committee Announces Candidates

A complete official ticket of candidates for the Institute offices that will become vacant August 1, 1933, was selected by the national nominating committee at its meeting held at Institute headquarters, New York, December 6, 1932. This committee, in accordance with the constitution and bylaws, consists of 15 members, one selected by the executive committee of each of the 10 Geographical Districts, and the remaining 5 elected by the board of directors from its own membership.

The following members of the committee were present: L. B. Chubbuck, Hamilton, Ont.; A. B. Cooper, Toronto, Ont.; F. M. Farmer, New York, N. Y.; L. B. Fuller, Salt Lake City, Utah; J. Allen Johnson, Buffalo, N. Y.; J. O. Kammerman, Rapid City, S. D.; A. E. Knowlton, New York, N. Y.; F. H. Lane, Chicago, Ill.; W. S. Lee, Charlotte, N. C.; F. J. Meyer, Oklahoma City, Okla.; A. C. Stevens, Schenectady, N. Y.; John Wells, Baltimore, Md.; H. R. Woodrow, Brooklyn, N. Y.; G. J. Yundt, Atlanta, Ga.; and H. H. Henline, New York, N. Y., secretary of the committee. Past-President W. S. Lee was elected chairman of the committee.

Following is a list of the official candidates selected by the committee:

For President

John B. Whitehead, professor of electrical engineering and dean of the faculty of engineering, The John Hopkins University, Baltimore, Md.

For Vice-Presidents

Middle Eastern District (No. 2): A. M. Wilson, professor of electrical engineering, University of Cincinnati, Cincinnati, Ohio.

Southern District (No. 4): F. M. Craft, chief engineer, Southern Bell Telephone and Telegraph Company, Atlanta, Ga.

North Central District (No. 6): R. B. Bonney, educational director, Mountain States Telephone and Telegraph Company, Denver, Colo.

Pacific District (No. 8): R. W. Sorensen, senior professor of electrical engineering, California Institute of Technology, Pasadena, Calif.

Canada District (No. 10): A. H. Hull, station engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ont.

For Directors

P. B. Juhnke, chief load dispatcher, Commonwealth Edison Company, Chicago, Ill.

Everett S. Lee, engineer in charge, General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

L. W. W. Morrow, editor, *Electrical World*, New York, N. Y.

For National Treasurer

W. I. Slichter (incumbent), professor of electrical engineering, Columbia University, New York, N. Y.

The constitution and bylaws of the Institute provide that the nominations made by the national nominating committee shall be published in the January issue of Electrical Engineering. Provision is made for independent nominations as indicated in the following excerpts from the constitution and bylaws:

Constitution

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the National Nominating Committee not later than February 15 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the National Nominating Committee in accordance with Article VI of the Constitution and sent by the National Secretary to all qualified voters during the first week in March of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) National Nominating Committee
by H. H. Henline
Secretary

Biographies of Nominees

That those not personally acquainted with the nominees may know something of them and their qualifications for the Institute offices for which they have been recommended, brief biographical sketches are given on p. 60–63 of this issue.

A.S.M.E. Holds Annual Meeting

The 53rd annual meeting of The American Society of Mechanical Engineers was held in New York, N. Y., December 5–9, 1932, with headquarters in the Engineering Societies Building. The engineering papers presented covered the usual broad range of subjects, and in addition several interesting lectures on economic subjects were given. The practice followed during the convention of a year ago of having a short lecture each morning at 8:50 on the subject of "Talking With an Audience" was continued. This feature was considered particularly successful as it assisted those presenting papers to obtain the proper attitude toward their talk.

Election of officers for 1932–33 was announced as follows: President, A. A. Potter; vice-presidents, H. V. Coes, J. D. Cunningham, and C. F. Hirshfeld (A'05); managers, R. L. Sackett, A. D. Bailey, and J. A. Hunter. A personal item on Doctor Hirshfeld's nomination was given in Electrical Engineering for October 1932, p. 748.

Executive Committee Meets in Place of Board

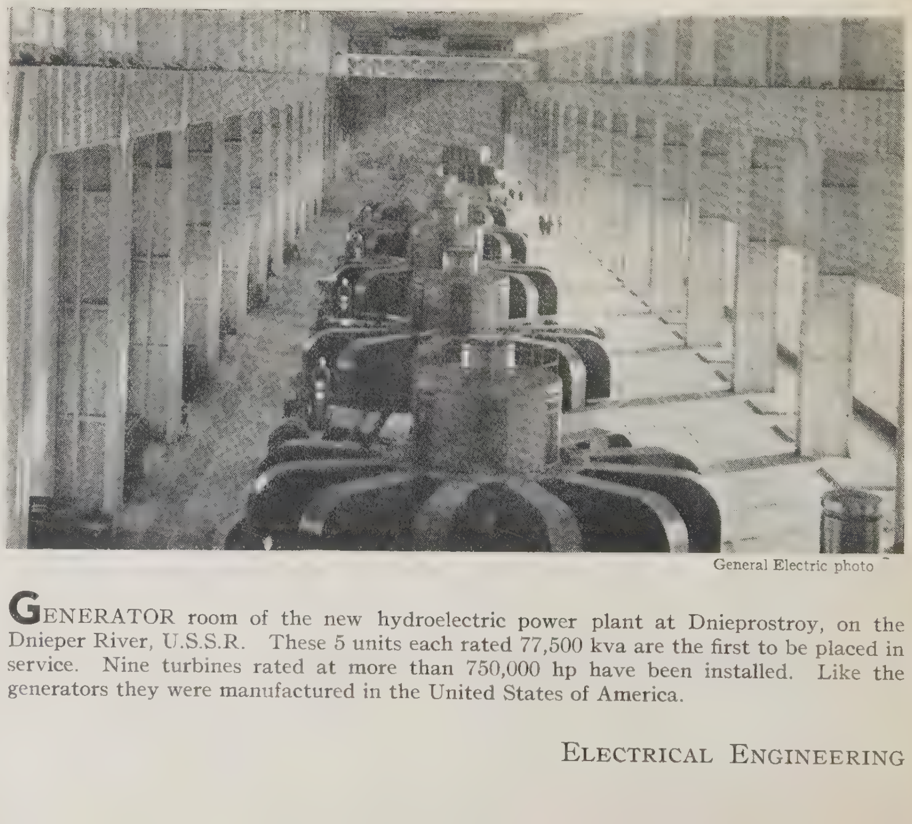
In accordance with action of the board of directors, in October, a meeting of the executive committee of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on Tuesday, December 6, 1932, in place of the regular December meeting of the board of directors.

There were present: Chairman H. P. Charlesworth, New York, N. Y.; J. Allen Johnson, Buffalo, N. Y.; E. B. Meyer, Newark, N. J.; F. W. Peek, Jr., Pittsfield, Mass.; W. I. Slichter, New York, N. Y.; and Acting National Secretary H. H. Henline, New York, N. Y.

In memory of Past-President R. F. Schuchardt the committee adopted a resolution which is published elsewhere in this issue.

A report of a meeting of the board of examiners held November 9, 1932, was presented and approved. Upon the recommendation of the board of examiners, the following actions were taken upon pending applications: one applicant was reinstated and 2 applicants were transferred to the

First 5 Generators at Dnieprostroy



General Electric photo

Generator room of the new hydroelectric power plant at Dnieprostroy, on the Dnieper River, U.S.S.R. These 5 units each rated 77,500 kva are the first to be placed in service. Nine turbines rated at more than 750,000 hp have been installed. Like the generators they were manufactured in the United States of America.

grade of Fellow; one applicant was reinstated, 5 applicants were elected, and 12 were transferred to the grade of Member; 37 applicants were elected to the grade of Associate; 427 Students were enrolled.

The finance committee reported approval, for payment, of bills amounting to $17,651.99 for the month of November.

It was reported that the papers presented at the Middle Eastern District meeting held in Baltimore, in October, amounted to about 6 pages in excess of the revised budget allotment for that meeting, and that the District Meeting committee had reimbursed the national treasury for the expense of printing these extra pages.

The appointment by the president of H. B. Gear (A'01, F'20) as a member of the Edison Medal Committee for the unexpired term, ending July 31, 1934, of R. F. Schuchardt (deceased) was confirmed.

Farley Osgood (A'05, F'12) was reappointed a representative of the Institute on the assembly of American Engineering Council for the term of 2 years, beginning in January 1933, and C. O. Bickelhaupt (M'22, F'28) was designated as chairman of the A.I.E.E. delegation in that Assembly.

The resignation of T. J. Fleming as Local Honorary Secretary of the Institute for Argentina was presented. It was decided not to fill the vacancy.

Authorization was given for the organization of Student Branches of the Institute at George Washington University, Washington, D. C., and the University of Porto Rico, Mayaguez, P. R.

The vacancy in the position of National Secretary of the Institute was filled by the appointment of H. H. Henline, now Acting National Secretary, to take office January 1, 1933.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

Executive Committee of District No. 5 Meets

The annual meeting of the executive committee of the Institute's Great Lakes District (No. 5) was held October 24, 1932, at Chicago, Ill. Present were:

K. A. Auty, vice-president A.I.E.E., and chairman of District executive committee
A. G. Deward, District secretary
L. R. Mapes, chairman, Chicago Section
D. L. Smith, secretary, Chicago Section
O. E. Hauser, chairman, Detroit-Ann Arbor Section
C. M. Summers, secretary, Fort Wayne Section
E. G. Thoms, chairman, Indianapolis-Lafayette Section
L. F. Wood, chairman, Iowa Section
R. E. Johnson, secretary, Madison Section
C. D. Brown, secretary, Milwaukee Section
R. R. Herrmann, secretary, Minnesota Section
E. A. Reid, chairman, Urbana Section
F. A. Kartak, representing W. F. Lent, chairman, Milwaukee Section
J. E. Kearns, director A.I.E.E.

In the election of a treasurer for the District executive committee for the coming year, K. A. Auty was unanimously elected to succeed himself. The committee on award of District prizes for the Great Lakes District was elected, consisting of Edward Bennett, A. H. Lovell, and F. R. Innes. F. H. Lane was elected to represent the Great Lakes District on the national nominating committee. A motion was passed that P. B. Juhnke be supported as a director of the Institute for the year 1933–34. (Mr. Juhnke has since been elected as a director of the Institute.)

The coordinating committee of the District consists of the vice-president, District secretary, chairman of the committee on student activities, and 4 members elected from the District executive committee. The following were elected to fill these 4 positions: R. E. Johnson, L. F. Wood, E. G. Thoms, and B. A. Case.

The report of the 1932 Great Lakes District meeting disclosed that the following 2 factors contributed to the success of this meeting:

1. The convention committee was made up of members chosen because their local affiliations made them valuable in arousing interest in the preparation of papers and in attendance at the convention.
2. Practically all papers presented at the convention were prepared by members affiliated with Sections lying within the Great Lakes District.

Following a report from the various Sections and a discussion of general business, the meeting was adjourned.

In Memoriam

R. F. SCHUCHARDT

WHEREAS, the death on October 25, 1932, of Rudolph Frederick Schuchardt, a member of this Institute for nearly thirty years, chief electrical engineer of the Commonwealth Edison Company, removed from central station engineering one of its outstanding leaders, and from the Institute a member who had served enthusiastically and effectively in many of its activities;

WHEREAS, through his services as a member of many important Institute committees, as vice-president 1922–1924, and as president 1928–1929, wherein he constantly exhibited great enthusiasm, high ideals, and a keen interest in the development of individual engineers, he made many notable contributions to the activities of the Institute;

WHEREAS, his forceful, but pleasing personality, his steadfast adherence to principles of the highest types, and his splendid qualifications as an electrical engineer won him the respect and admiration of many friends, be it therefore

RESOLVED: That on behalf of the membership the executive committee of the American Institute of Electrical Engineers hereby expresses its deep sorrow at the death of Mr. Schuchardt; and be it further

RESOLVED: That these resolutions be entered in the minutes and copies be transmitted to members of his family.

Engineering Instruction Reorganized at Yale

Further plans in the organization of the Yale School of Engineering have recently been announced with the appointment of Professor R. E. Doherty as dean. The school of engineering is the result of a reorganization of the division of engineering in the Sheffield Scientific School and the graduate school at Yale, whereby engineering work of all grades, together with research and other activities in the engineering department, are combined in a distinctive unit within the university and operating under the leadership of Dean Doherty. The school will include the functions and activities in civil engineering (including drawing) chemical, electrical, and mechanical engineering, metallurgy, and engineering mechanics. All students of engineering will be under the jurisdiction of an engineering faculty, and the engineering degrees will be conferred upon its recommendation. An item regarding Dean Doherty is given in the "Personal" columns of this issue.

Extra Session to Be Held by Harvard Business School.—To meet the demands of college men graduating at mid-year with no positions in view, and because of unemployment prevalent among recent college graduates, the Harvard Business School will hold an extra session starting January 30, 1933, and continuing through August 16, 1933. The usual requirements for admission will be observed; the extra session will be opened to students with degrees from accredited colleges and a limited number of well recommended men with executive business experience. Those who attend the session will have the same instruction under the same faculty as students in the regular first year class, and will be entitled to full academic credit, thus enabling them to enter the second year class next fall. Applications should be made before January 16, 1933. For further information address the secretary, Graduate School of Business Administration, George F. Baker Foundation, Harvard University, Boston, Mass.

Hoover Power Plant Equipment Bids Asked

According to information released by the Bureau of Reclamation, U.S. Department of the Interior, Washington, D. C., contracts are about to be placed for the initial installation of turbines in the power plant at the Hoover Dam. The bureau is advertising for bids on furnishing 5 115,000-hp and 2 55,000-hp hydraulic turbines. Many of the features of the Boulder Canyon project are superlative, and in this instance the turbines are the largest hydraulic units ever constructed, far exceeding in size those in the Dnieper (Russia) plant and those being constructed for the Diablo plant in Washington. The Hoover plant turbines will work under a maximum head of 590 ft and an average head of 530 ft. Invitations to bid have been sent to the Pelton Water Wheel Company, Allis-Chalmers Manufacturing Company, S. Morgan Smith Company, Newport News Shipbuilding & Dry Dock Company, and other waterwheel manufacturers. From 620 to 1,435 days are allowed for delivery. Bids will be asked on turbines with or without 14-ft and 10-ft diam butterfly valves, and on governors for each turbine.

About $17,000,000 is expected to be expended for machinery to be installed in the power plant by the government. The capacity of the plant will be 1,835,000 hp, or more than 3 times the capacity of either the Niagara Falls (United States) or Wilson (Muscle Shoals) plant. According to the present progress schedule, work on the power plant will start in February 1933, the 2 wings will be completed in September 1934, and the center portion in July 1937. The first unit of the power plant is scheduled to be in operation by September 1935.

American Engineering Council

Federal Public Works to Be Curtailed in 1933

In dealing with measures necessary to balance the federal budget for the coming fiscal year, President Hoover in his message to Congress on December 6, 1932, stated that the budget as submitted will provide only for the completion of federal public works and projects already undertaken or under contract. He stated that the speeding up of federal works during the past 4 years as an aid to employment had advanced many types of such improvements to the point where further expansion could not be justified in their usefulness to the government or to the people. He stated further that as an aid to unemployment, reproductive or so-called self-liquidating work should be substituted beyond the normal constructive program.

The federal construction program thus limited to commitments and work in progress under proposed appropriations contemplates expenditures for the next fiscal year, including naval and other vessel construction as well as other forms of public works and maintenance thereof, a total of $42,769,000 as compared with $717,262,000 for the present year.

R.F.C. Authorizes 13 Additional Loans.—In addition to loans authorized on November 1, 1932, the Reconstruction Finance Corporation authorized 13 additional loans for self-liquidating projects during the month of November. These loans totaled $4,778,000 making the grand total of loans authorized up to and including November 30 to $139,397,500. Of the 13 loans authorized in November, 8 were for construction or extension of water supply systems; 2 for construction or extension of sewer systems; 2 for toll bridges; and 1 for flood control and drainage. The loans ranged in size from $10,000 to $1,700,000 indicating that the hopeful trend toward relatively small, well distributed loans has continued throughout November.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

A Suggestion Concerning Conventions

To the Editor:

The present organization of conventions does not provide an opportunity for proper discussion of important technical subjects confronting the institute. I wish to take the liberty to suggest modifications in the organization of the conventions which I believe would permit more satisfactory utilization of convention opportunities.

The large number of papers generally presented at conventions limits the length of presentation to 10 minutes and that of the discussion to 5 minutes per speaker. These periods are sufficiently long only for a very brief statement of the contents of the paper by the author and of views and questions of a few members of the audience. They are not sufficient for the development of the arguments in support of the views expressed either in the paper or in the discussions. This is particularly true where conflicting views are entertained by various authorities.

This time limitation becomes particularly unsuitable in the case the subject of a paper is so new that its basic principles and the order of magnitude of the essential quantitative relations are not generally known or appreciated by the membership. In such a case a conflict even between experts is quite natural and perhaps unavoidable.

On an average the presentation of papers, combined with introductions of the authors by the chairman occupy about 40 per cent of the entire time devoted to the meetings. Presentation is nothing but a brief statement of the contents of the paper—which generally appears on the pages of the ELECTRICAL ENGINEERING soon after the convention. Proper arrangement of the schedule of publications will permit the abridged papers being published preceding the conventions. The convention meetings then can be devoted entirely to the discussion of these papers, with presentation of the papers eliminated from the procedure. I understand that some of the engineering societies follow a procedure similar to this.

On some, relatively rare, occasions conflicting views are entertained by various groups of engineers on subjects of considerable importance to the industry. In such cases even the elimination of presentation of the paper, as suggested, may not be sufficient to provide necessary time for adequate discussion. The number of members seriously interested in the discussion of such subjects generally is a small fraction of the entire attendance at the convention. To give this group of engineers a better opportunity to discuss adequately these subjects I would like to suggest organization of round table meetings. Such meetings can take place in the small rooms of the Institute, thereby freeing the majority of those attending the convention from being obliged to listen to lengthy discussions of topics in which they are not sufficiently interested.

At present, on account of lack of time at the convention the opponents are obliged to turn to written discussions as the only avenue left to them. These written discussions often are not free from fundamental misunderstandings, as generally is characteristic of a single written exchange of conflicting views.

I believe that the principal purpose of the A.I.E.E., the advancement in the art, can be served to better advantage by round table discussions, limited to those engineers who are sufficiently interested to attend them. Such discussions can be scheduled after the presence of fundamental disagreement or the lack of understanding of important phases of any subject becomes evident. Therefore, several months may elapse between presentation of the first paper and the round table meeting. These meetings, therefore, would be held during some subsequent convention.

In addition to providing the room, the Institute could help greatly by compiling the list of subjects for a series of round table meetings and by providing a convenient means for individual members to make the suggestions of the topics.

Very truly yours,

K. K. PALUEFF
(Power Transformer Department, General Electric Company, Pittsfield, Mass.)

Mechanical Analogs of Electric Circuits

To the Editor:

The fundamental relationship between electrical and mechanical systems, referred to in the "Letter to the Editor" by J. G. Brainerd in the August 1932 issue of ELECTRICAL ENGINEERING, p. 598–9, is clearly demonstrated to the touch as well as to the eye by means of a model which I constructed some years ago and which is now at the Massachusetts Institute of Technology.

This model, as shown in Fig. 1, consists of a driving element carrying a dial marked "Pressure," elastic belt, and a driven element. The driven element has a fan, a flywheel, and a spring return mechanism, which can be connected to the shaft in any desired combination. The driving element has a floating dial marked "Flow," which is belted to the driven element by means of a non-elastic belt. The whole constitutes a mechanical analog of a typical electrical system, consisting of a generator, feeder, and receiving circuit, with means for indicating the instantaneous phase relation between voltage and current, or pressure and flow.

The various parts of the model do not represent actual visible pieces of electrical apparatus. They represent the internal and invisible electromagnetic and dielectric structures whose interaction is responsible for the behavior of the system under any given set of conditions. This behavior of the system is commonly evident only through the medium of instrument readings, which give no graphic picture of what is going on inside the apparatus itself. In watching the performance of the model the observer is looking behind the scenes of the electric circuit, much as a physician, with the aid of the X-ray, watches the internal processes of the human body.

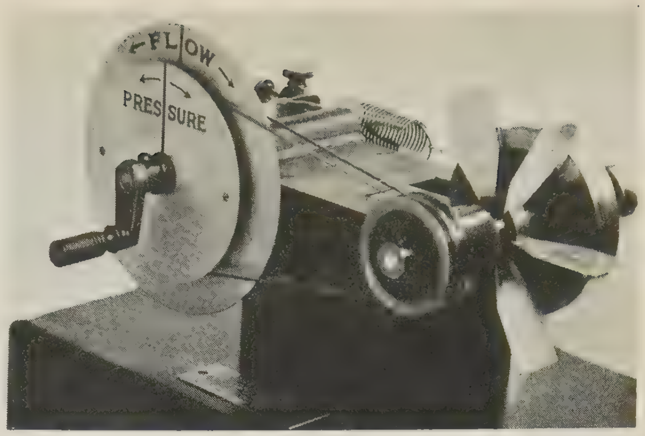


Fig. 1. Model illustrating the relationship between mechanical and electrical systems. A d-c system is illustrated by continuous rotation of the crank in one direction, and an a-c system by harmonic oscillation of the crank back and forth

CORRESPONDENCES

In general the mechanical elements of the model correspond to the internal structures of the electrical system as follows:

1. Any element displaying fluid friction (windage) corresponds to a non-reactive electric circuit.
2. Any element having inertia corresponds to an electromagnetic circuit.
3. Any element having springiness (elasticity) corresponds to a dielectric circuit.
4. Velocity of any part corresponds to flow of electric current.
5. Force exhibited or applied at any point corresponds to electrical pressure (emf).
6. Fluid friction (windage) corresponds to resistance (and non-inductive load).
7. Inertia corresponds to inductance.

The detailed analogy between the mechanical and electrical systems demonstrated in this model may be of interest to some of your readers, and is given in Table I.

Table I—Analogy of Mechanical and Electrical Quantities

Mechanical		Electrical	
Fluid Friction		**Ohmic**	
Moment of fluid friction	R	Resistance	R
Torque (applied)	T	Emf (applied)	E
Velocity (angular)	$\omega = \frac{T}{R}$	Current	$I = \frac{E}{R}$
Power	$P = \omega^2 R = T\omega$	Power	$P = I^2 R = EI$
Energy	$w = \omega^2 Rt = T\omega t$	Energy	$w = I^2 Rt = EIt$
Kinetic		**Electromagnetic**	
Weight	$M = \delta A l$	Permeance	$\mathcal{P} = 4\pi\mu \frac{A}{l}$
(δ = density, A = area, l = length)		(μ = permeability, A = cross section, l = length of magnet circuit)	
Radius of gyration	K	No. of turns	N
Moment of inertia	$I = MK^2$	Inductance	$L = \mathcal{P} N^2$
		Current (instantaneous)	i
Momentum	$I\omega$	Flux	$\phi = Li$
Acceleration	$\alpha = \frac{d\omega}{dt}$	Rate of change of current	$\frac{di}{dt}$
Torque	$T = I\alpha$	Emf	$e = L\frac{di}{dt}$
Power	$P = I\omega \frac{d\omega}{dt}$	Power	$P = Li\frac{di}{dt}$
Stored energy	$w = \frac{I\omega^2}{2}$	Stored energy	$w = \frac{Li^2}{2}$
Static		**Dielectric**	
Elasticity	$e = \frac{8}{E}$	Permittivity	k
(E = torsional modulus of elasticity)			
Volume factor	$V = \frac{D^3}{d^4}$	Volume factor	$V = \frac{a}{4\pi l}$
(D = mean diam of coil, d = diam of wire)		(a = area, l = thickness)	
Springiness	$S = Ve$	Capacity	$C = Vk$
Force (linear)	F	Emf	e
Extension	$L = SF$	Charge	$\Psi\ (Q) = Ce$
Stored energy	$w = \frac{SF^2}{2}$	Stored energy	$w = \frac{Ce^2}{2}$
Combined		**Transient**	
Instantaneous velocity	$\omega = \frac{T}{R}\left(1 - \epsilon^{\frac{-RT}{I}}\right)$	Instantaneous current	$i = \frac{E}{R}\left(1 - \epsilon^{\frac{-RT}{L}}\right)$
Total stored energy	$W = \frac{I\omega^2}{2} + \frac{SF^2}{2}$	Total stored energy	$W = \frac{Li^2}{2} + \frac{Ce^2}{2}$
Period of oscillation	$\tau = 2\pi\sqrt{IS}$	Period of oscillation	$\tau = 2\pi\sqrt{LC}$

This model has proved very useful in explaining the subject of power factor and lagging current to non-technical and even to technical people, and it has been copied by educational institutions for demonstration to students in electrical engineering courses.

Very truly yours,

R. W. ADAMS (M'12)
(District Manager, Central Station Dept., General Electric Co., Boston, Mass.)

Consumption, Production, Distribution

To the Editor:

The data on growth of productive power during the past century given by Bassett Jones in his letter in the November issue of ELECTRICAL ENGINEERING are extremely interesting because they show clearly the tremendous advance that should have been made in the living standard of every one of our people during that period. Such data tell us nothing, however, as to why we are not continuously using that productive power for this purpose. This is a separate and distinct problem and while the survey being conducted by "Technocracy" must be an interesting hobby, it is unfortunate to the extent to which it has diverted the attention of intelligent investigators from the problem of the day. Let us hope the American Engineering Council will not be similarly diverted.

When Mr. Jones concludes that purchasing power cannot be measured in terms of price he is utterly wrong and yet very near the truth. Price is a measure of the value of an article and purchasing power is the measure of an individual's ability to demand goods on the markets of the world. Both are today, and must always be, measured in some convenient units, which units are known as the medium of exchange or more commonly as money. On the other hand, the monetary system by which prices are set must be capable of performing its function of pricing with the necessary

degree of accuracy, and this our present monetary system—the gold standard—does not and from its very nature cannot do. To this extent only is Mr. Jones correct in his conclusions.

The security back of the 224 billion dollars of debt to which Mr. Jones refers is not the 4 billion dollars of gold but several hundred billion dollars worth of valuable property. The existence of this debt does not condemn money, price, or the law of supply and demand; it merely condemns a monetary system under which we are dependent on debt (bank credit) for purchasing power. The moment we begin paying debt to the bankers faster than others find profitable opportunities to borrow it for the purchase of consumers goods or new capital goods, we decrease national purchasing power and start the down trend of a business cycle. This is called deflation of credit by the bankers as being a less disturbing way of expressing it. Conversely the bottom of the depression comes when opportunities to go profitably into debt exceed the rate of forced liquidation.

Thus under the gold standard we are dependent on some one going into debt for an opportunity to earn a living, and this debt can never be paid because the attempt to do so precipitates a depression. Is it any wonder that "Technocracy" finds that debt expanded at the 4th power of the time from 1840 to 1930. It has decreased since 1930 due to forced liquidation and defaults, but must be rebuilt before business can be brought back to normal. This shows why a high productive power does not permit us to prosper continuously and to raise our living standard universally. We depend on a high rate of growth of productive power to keep business moving, since this involves a rapid expansion of capital goods and of debt. That this rapidly expanding productive power periodically outruns its market is an essential factor in the periodic deflations by which the gold standard keeps prices under control.

This explains why engineers and business men are today standing by, waiting for utilities, railroads, industrials, and governments to go further into debt in order that we may return to work. The report of the A.E.C. is very close to the truth in pointing out that when high profits are not spent but are used to pile up huge surpluses and, of course, they should have added to deflate debts, national income and buying power decrease and the cumulative process of forced liquidation and business depression begins.

Mr. Jones asked a pertinent question, "Well what is the answer?" With the foregoing facts in mind the answer is obvious. It is a monetary system that will automatically introduce into circulation exactly the right amount of new money to maintain national income when debt is being deflated, and which will automatically withdraw from circulation the right amount of money when debt is being inflated. Such a money would permit the steady deflation of the existing debt structure by payment out of profits and earnings rather than by cancellations and defaults. It would end unemployment and would permit the *voluntary* increase of leisure that should accompany the steady growth of energy per capita.

There is no space here in which to show how the requirements for a satisfactory money eliminate all possibilities but one, the substitution of public works for gold as the money standard. (Attention has been drawn to this in the public press from time to time and it has been completely described in a small book "The Cause and Cure of Unemployment.") Suffice it to say that the average commodity price level would be under positive control, that involuntary unemployment would be permanently ended, that neither inefficiency nor dishonesty of public officials could affect the stable buying power of the dollar, that it is purely individualistic, all wealth owned by individuals, and all business conducted by them, that the details of operation have been completely worked out and are simple and straightforward compared to the gold standard, and that it can be put immediately into operation without change in government or industry.

Whether or not any other answer is possible may be open to argument, but here is an answer that fulfils all the requirements, that is simple, direct, and obvious and against which none of the many economists to whom it has been submitted have found any objections, except the normal objection of conservative minds to change of any kind.

Very truly yours,
John S. Lennox (A'23)
(214 Dawes Ave.,
Pittsfield, Mass.)

Personal

J. B. Whitehead Nominated for Presidency

John Boswell Whitehead (A'00, M'08, F'12, Life Member) dean of the faculty of engineering at The Johns Hopkins University, Baltimore, Md., has been nominated for the presidency of the A.I.E.E. for the 1933–34 term. He was born August 18, 1872 in Norfolk, Va., a son of Henry Colgate and Margaret Walk (Taylor) Whitehead. After preparatory education he entered The Johns Hopkins University in 1889, studied electrical engineering under Duncan and Rowland, and was granted his first degree in 1893. After an early period of professional work he returned (October 1897) to Johns Hopkins and completed the requirements for the degrees of Bachelor of Art (1898) and Doctor of Philosophy (1902). Leaving Johns Hopkins in 1893, Dr. Whitehead entered the Westinghouse Electric & Manufacturing Company, passing a year in the shops as an apprentice and then 2 years in experimental development and design of transformers where his immediate superior was Dr. Charles F. Scott. In 1896 he went to Niagara Falls with the first generators of the Niagara Falls Power Company and passed a year as operating engineer with that company in the initial stages of the operation of its plant. After completing his graduate work at Johns Hopkins he was (1902) research assistant in the United States Bureau of Standards, and (1902–5) research assistant of the Carnegie Institution of Washington working in the laboratories of Johns Hopkins University at Baltimore. In 1904 he was appointed associate professor in electrical engineering at Johns Hopkins, becoming full professor in 1910, and dean of the school of engineering in 1919. While Dr. Whitehead's chief identification has been with education and research, he also has engaged actively in practice as a consulting engineer. He was consulting engineer to the Baltimore and Annapolis Short Line Railroad (1906–8) during its electrification and also to the Johns Hopkins University (1900–08) at the period of its removal to its new site in the suburbs of Baltimore and the construction of its power plant, during which time he was in charge of the university's power plant and electrical equipment. In later years with the development of his chief interest in high voltage insulation, he has had an extensive consulting practice in this field. Closely related to this work have been services as consultant and director of research for various projects supported by the National Electric Light Association, the Utilities Research Commission of Illinois, and the Engineering Foundation, many of the results of which work have been published by the Institute. Dr. Whitehead has been active in Institute affairs for many years and a regular contributor to Institute publications for more than 20 years. He was the founder of the Baltimore Section and for 19 years its chairman. He has served as a member of the board of directors (1924–8); as chairman of the electrophysics committee (1912–16) and the research committee (1922–7); at various times as a member of committees on electrophysics, electrochemistry and electrometallurgy, code of principles of professional conduct, education, technical activities, meetings and papers, and others. Since its inception he has been identified with the work of the committee on research. The Institute selected him as a representative on the Division of Engineering and Industrial Research of the National Research Council, and as its delegate to the Conference Internationale des Grand Reseaux Electriques, Paris, France, 1927. Dr. Whitehead is a member of the National Academy of Sciences, Fellow of the American Physical Society, and Member of the National Institute of Social Sciences, the American Association for the Advancement of Science, the Société Française des Electriciens. He was the organizer (1927) of the committee on electrical insulation of the National Research Council's division of engineering and industrial research, and since that time has served continuously as its chairman. He was an exchange professor to France in 1926–27. Honors awarded him include the Edward Longstreth Medal and the Elliott Cresson Gold Medal of the Franklin Institute, the Triennial Prize (1922 and 1925) of the Institute Elektrotechnique Montefiore Liege, Belgium, and the Medaille d'Honneur of the University of Nancy, France, 1927.

Vice-Presidential Nominees Are Bonney, Craft, Hull, Sorensen, Wilson

Alexander Massey Wilson (A'09, M'18) nominee for vice-president of the A.I.E.E. representing the Middle Eastern District (No. 2) was born August 31, 1876, at Stranraer, Scotland. After preliminary education he entered Purdue University, Lafayette, Ind., whence he pursued engineering studies, leading first to a degree of Bachelor of Science in mechanical engineering (1901) and continued to the completion of the requirements for the degree of mechanical engineer, which he was awarded in 1903. During the summers of 1899 and

1900 Professor Wilson, as a student, began to acquire practical experience in the woodworking shops of the N.Y.C. & St. L.R.R. shops in Chicago; the summers of 1901 and 1902 in the roundhouses of the Big Four Railroad at Indianapolis, Ind., where he did some testing of locomotives. During the summer of 1903 he engaged in design work for Heyl and Patterson in Pittsburgh, Pa. With the beginning of the academic year of 1902, Professor Wilson became assistant and instructor in the mechanical engineering department at Purdue University, which position he held until March 1904, when he went to the state college of Kentucky in Lexington as assistant professor of electrical engineering, receiving full professorship in September 1905. In 1911, Professor Wilson transferred his affiliation to the University of Cincinnati (Ohio) where he became professor of electrical engineering and where, from that time to the present, he has been in charge of the electrical engineering course. In addition to his educational work, Professor Wilson has had consulting experience in various branches of the engineering field. He has taken active part in the National Electric Light Association committee work; was a member of the engineering committee that drew up the present administrative order for the state of Ohio covering the transmission problems common to the railroad, telegraph and telephone, and power companies. Professor Wilson served the Engineers' Club of Cincinnati as president (1917–18); was a member of the A.I.E.E. committee on education (1924–25).

Robert Bridge Bonney (A'03, M'18) nominated for the vice-presidency of the Institute to represent the North Central District (No. 6) since 1915 has been educational director for the Mountain States Telephone and Telegraph Company, with headquarters in Denver, Colo. He was born September 25, 1877, in Dedham, Mass.; educated in the public schools of Dedham and Duxbury, Mass.; graduated from Partride Academy and High School, Duxbury, in 1895. His technical education was acquired through practical work and study including various correspondence courses during his first 7 years or so in the employ of the Colorado Telephone Company, Denver, with which company he became affiliated August 1, 1895. Starting in with that company as shop helper, he worked in various departments later (1897) becoming a switchboard installer. From that date he handled switchboard installation work throughout the state of Colorado. In July 1903 he became wire chief in the main exchange in Denver, subsequently becoming assistant superintendent of maintenance (February 1, 1905) and superindent of maintenance (February 1, 1906). He was in the traffic department from July 1, 1906, until January 16, 1907; then in the equipment engineering department until October 31, 1907, at which time he left the employ of the telephone company to enter engineering work on his own account. In January 1909, Mr. Bonney was employed by the Central Colorado Power Company and later supervised the operation of that company's private telephone system. On April 25, 1910, he reentered the employ of the Colorado Telephone Company, in Denver, as assistant equipment engineer, which position he continued to hold after his company was succeeded in 1911 by The Mountain States Telephone and Telegraph Company. Departing from the engineering and operation, Mr. Bonney was appointed November 1, 1915, as educational director of his company, and took up the development of an educational plan designed for the purpose of training company employees along the technical and other lines pertaining to the company's business. For his work in education and special training during the national emergency of 1917–18, Mr. Bonney was awarded the U.S. War Department's Certificate for Marked Service. He is active in local civic and other affairs; served the Colorado Engineering Council as its president for a 2-year term ending June 30, 1932. In Institute affairs Mr. Bonney has been active for many years; served as secretary of the Denver Section continuously from the date of its organization, May 18, 1915, to the close of the administrative year July 31, 1930; was Section chairman (1930–31); a member of the national membership committee (1925–26 and 1927–28).

Arthur Harvey Hull (A'09, M'18) recently nominated to serve the A.I.E.E. as vice-president representing the Canadian District (No. 10) has, since 1913, been affiliated with the electrical engineering department of the Hydro-Electric Power Commission of Ontario, Canada, as assistant engineer on station design; for the past several years he has been in charge of the station section of that department. Mr. Hull was born February 6, 1886, in Cayuga, Ontario, where he attended grade and high schools; subsequently (1903) he entered the University of Toronto, where after completing an electrical engineering course he graduated in 1908 with the degree of Bachelor of Applied Science. Early practical training obtained while a student included service in the machine shop of the Smart-Turner Machine Company at Hamilton, Ontario (1905), and service as an engineering apprentice with the Canadian Westinghouse Company at Hamilton, during parts of 1906, 1907, and 1908. In 1909 Mr. Hull joined the staff of Smith, Kerry & Chase, consulting engineers of Toronto, where he served first as a draftsman on station design subsequently taking charge of the electrical drafting room; later he went to Calgary, Alberta, to assist in supervising the initial operation of a 13,000-kva hydroelectric plant for the Calgary Power Company, on the design of which plant he had been working for some time. Returning to Toronto, he took charge of factory inspection of apparatus for his firm. In 1913, he left Smith, Kerry & Chase to become a part of the organization of the Hydro-Electric Power Commission of Ontario, as previously mentioned. Mr. Hull's club memberships include the Engineers' Club of Toronto, and Hart House, University of Toronto. He has been a registered member of the Professional Engineers Association of Ontario since 1922; served as counselor of that organization during 1925 and 1926. His Institute membership dates from his student enrolment in 1906. He has served the Institute as chairman of the Toronto Section (1918–19); as a member of the committee on power generation (1928–33).

Francis Marion Craft (A'24, M'27) recently nominated to serve the Institute as a vice-president representing the Southern District (No. 4) is chief engineer of the Southern Bell Telephone and Telegraph Company with headquarters in Atlanta, Ga. Mr. Craft was born in Cortland, Ohio, October 27, 1883; attended grade and high schools in Warren, Ohio, subsequently entering Ohio State University, from which he graduated in 1905 with the degree of mechanical engineer in electrical engineering. He was employed by the Western Electric Company in Chicago and Hawthorne, Ill., from July 1905 to December 1915, first as a student engineer, and later in various capacities in the central office equipment engineering department where he handled telephone switchboard engineering problems. In January 1916, Mr. Craft became associated with the Chesapeake and Potomac Telephone Company serving successively as central office equipment engineer in Baltimore (1916–18); resident engineer in Washington, D. C., during the war period (1918–19); engineer of machine switching equipment in Baltimore (1919–20); and as equipment engineer in Baltimore (1920–31). Going to Omaha, Neb., in February 1921, Mr. Craft served the Northwestern Bell Telephone Company as building and equipment engineer until May 1923, at which time he was employed by the Ohio Bell Telephone Company, Cleveland, as equipment and building engineer, a position which he held until August 1925. Since August 1925 Mr. Craft has been serving the Southern Bell Telephone and Telegraph Company as chief engineer, in which office he is responsible for the design of the physical property and for general supervision over the construction of new plants throughout the company's system which operates in 9 southeastern states. Mr. Craft is a member of the (Atlanta) Capital City Club, Sigma Xi, and Tau Beta Pi; a director of American Engineering Council, and of the Atlanta Chamber of Commerce.

Royal Wasson Sorensen (A'07, M'13, F'19) senior professor of electrical engineering at California Institute of Technology (Pasadena) has been nominated to serve the Institute as vice-president representing the Pacific District (No. 8). He was born at Alta Vista, Kan., April 25, 1882; while a boy moved to Colorado where he attended high school at Golden. From the University of Colorado at Boulder he received the degrees of Bachelor of Science in electrical engineering (1905) and Electrical Engineer (1928). From 1889 to 1905, while still a student, he engaged in various activities of an electrical nature, ranging from doorbell wiring to stringing power lines and operating power plants. Upon graduation in 1905, he entered the test department of the General Electric Company at Schenectady, N. Y., as student engineer. In March 1906 he became foreman of the test department at Schenectady, and in October

of that same year was transferred to the commercial section of the transformer engineering department, ultimately (February 1908) being transferred to the Pittsfield (Mass.) works. In September 1910, Professor Sorensen became associate professor of Electrical Engineering at the (then) Throop Polytechnic Institute. In September 1911, Professor Sorensen was made full professor of electrical engineering, a position he has occupied continuously since that time. In addition to his educational work Professor Sorensen engaged in a consulting practice, serving (1913–17) the one-time Pacific Light and Power Corporation of Los Angeles, in connection with its problems incident to the construction and operation of its then record-breaking 150-kv Big Creek transmission system. Other work of a commercial nature has included research in connection with a vacuum type of circuit breaker (1929–30) and service (1917–32) as consulting engineer for the U.S. Electric and Manufacturing Company, Los Angeles, in connection with the development of methods of motor design. Professor Sorensen is active in local affairs; is past-chairman of the joint technical society and the Sigma Xi and Tau Beta Pi clubs of Los Angeles; a member of the Society for the Promotion of Engineering Education, and the American Association of University Professors; a member of the board of consulting engineers for the metropolitan water district of southern California. He has served the A.I.E.E. as a member of several of its committees including research, (1923–30); education (1924–28); instruments and measurements (1927–30); student branches (1927–28); has served the Los Angeles Section as secretary (1919–20) and as chairman (1920–21); was chairman of Pacific Coast convention committee (1924); is counselor for the Student Branch at "Cal. Tech." In addition to his committee work he has made several contributions to the Institute's technical literature.

Juhnke, Lee, Morrow Nominated for Institute Directorships

Paul Boniface Juhnke (M'20) recently nominated to serve the Institute as a member of its board of directors, is chief load dispatcher for the Commonwealth Edison Company, Chicago, Ill. He was born in Obkass, West Prussia, Germany, August 18, 1879. After coming to the United States in 1892, he completed his preliminary education in private preparatory schools and public high school, subsequently entering Lewis Institute, Chicago, graduating in 1903, with the degree of Mechanical Engineer. He became a naturalized citizen April 9, 1904. Mr. Juhnke has been affiliated with the Commonwealth Edison Company continuously since 1903. On July 19, 1903, he entered the employ of the company in its construction department, becoming a construction foreman in May 1904. In July 1904 he took up oil switch maintenance work for his company, transferring in February 1905 to the load dispatching office. In February 1911 his company appointed him chief load dispatcher and placed upon him responsibility for management of the load dispatcher's office, and for operation of the entire power system. Mr. Juhnke has several side interests: He served as president of the Interurban Public Service Corporation (1922–24) until that company was absorbed by the Public Service Company of Northern Illinois. He has been president of Lewis Union, his alumni association; is a member of the Western Society of Engineers (Chicago) and was chairman of its electrical section; has been active in engineering activities of the National Electric Light Association; is a member of the Daedalian Fraternity (Lewis Institute). Mr. Juhnke is active in efforts that he considers designed to improve the existing economic order; publishes a pamphlet "Everyday Economics," that is "devoted to a broader understanding of vital questions of the day." Mr. Juhnke served the A.I.E.E. Chicago Section as president for the administrative year 1928–29.

Everett Samuel Lee (A'20, M'28, F'30) recently nominated to serve the Institute as a member of its board of directors, is now engineer in charge, General Engineering Laboratory, General Electric Company, Schenectady, N. Y. Mr. Lee was born November 19, 1891, in Chicago, Ill., attended grammar school in Wilmette, and graduated in 1909 from the high school in Kenilworth, Ill. Attending the University of Illinois, Urbana, from 1909–13, he was graduated with the degree of Bachelor of Science in electrical engineering; graduate work pursued at Union College, Schenectady, N. Y., earned him in 1915 the degree of Master of Science in electrical engineering. Following graduation from the University of Illinois, Mr. Lee spent the summer of 1913 in the test department of the General Electric Company at Schenectady. In September 1913 he became an instructor in electrical engineering at Union College, where he also studied for his Master's degree, and where he continued as an instructor through June 1916, continuing also as a laboratory assistant in the general engineering laboratory of the General Electric Company. From June 1916 to September 1917 he was mechanical expert for the Locomotive Stoker Company of Chicago, serving as engineer in charge of tests in the western district (mechanical and railway engineering). Then he became officer-in-charge of machine gunnery of the U.S. Army School of Military Aeronautics convened at the University of Illinois, receiving his discharge in December 1918 as a first lieutenant. Returning to become division head of instruments and measurements in the general engineering laboratory, Mr. Lee has since been affiliated continuously with the General Electric Company. In September 1928 he was made assistant engineer of the laboratory and, on December 18, 1931, was appointed engineer in charge of the laboratory. In the activities of the A.I.E.E. Mr. Lee has been prominent for several years. He has served the Schenectady Section as chairman (1928–29); has served the Institute at large as a member of numerous committees including instruments and measurements (1927–33, chairman 1927–30); meetings and papers (1927–30); Sections (1929–33, chairman 1930–33); coordination of Institute activities (1930–33); special committee on Institute policies (1931–33); special committee on Associate dues and related matters (1932–33). Mr. Lee is the author of numerous technical papers, some of which have appeared in the Institute publications, and others of which have been published by the technical trade press. Most of these papers have had to do with instruments and methods for electrical measurements. Mr. Lee also is an active member of the American Society for Testing Materials, The American Society of Mechanical Engineers, and the American Standards Association; he is a member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi, University of Illinois Alumni Association, and the Edison Club of Schenectady.

Lester William Wallace Morrow (A'13, M'17, F'25) recently nominated to serve the A.I.E.E. as a member of its board of directors, is editor of *Electrical World* with headquarters in New York. Mr. Morrow was born at Hammond, W. Va., August 7, 1888; was educated in the public schools of Fairmont, W. Va., Fort Worth, Texas, and Amarillo, Texas; and completed his preparatory schooling at Marshall College, Huntington, W. Va. (1904–07). Entering Cornell University, Ithaca, N. Y., in 1907, he graduated in 1911 with the degree of Mechanical Engineer, immediately becoming an instructor in electrical engineering at Cornell. In 1913 he went to Norman, Okla., as assistant professor of electrical engineering in the University of Oklahoma, subsequently serving (1916–17) as associate professor of electrical engineering and acting director of the school of electrical engineering; during 1917–18, he was professor of electrical engineering and director of the electrical engineering school, serving during that period also as a member of the Oklahoma Bureau of Standards, and as secretary of the Oklahoma Utilities Association. During the war period (1918–19) Mr. Morrow served as assistant director of the U.S. Army Signal Officers' School at Yale University, New Haven, Conn. He was assistant professor of electrical engineering at Yale (1918–22) where he received in 1922 citation (Sigma Xi) for "special proficiency in teaching and executive ability." Leaving Yale in 1922, Mr. Morrow became affiliated with the McGraw-Hill Publishing Company, Inc., of New York, on the editorial staff of *Electrical World*, serving as associate editor (1922–24), managing editor (1924–28), and as editor since 1928. For some years Mr. Morrow has been an active participant in Institute affairs, serving on numerous committees including meetings and papers (1921–30, chairman 1923–25); chairman of committee on award of Institute prizes (1923–24); coordination of Institute activities (1923–25); publication committee (1923–25); chairman of special committee on Institute prizes (1925–26); board of examiners (1926–33); Lamme Medal (1928–30); Edison Medal (1929–34); committee on the engineering profession (1930–31); committee on legislation affecting the engineering profession (1931–33); special committee to consider Associate dues and related matters (1932–33); en-

gineers' council for professional development (1932–33); and chairman of the New York Section (1927–28). Mr. Morrow also is a member of The American Society of Mechanical Engineers, the Society for Promotion of Engineering Education, Sigma Tau, Sigma Xi, Epsilon Xi, Acacia, Cornell University Club (New York) and Graduate Club (New Haven, Conn.).

W. I. Slichter
Renominated as Institute Treasurer

Walter Irvine Slichter (A'00, M'03, F'12) professor of electrical engineering at Columbia University, New York, N. Y., has been nominated to succeed himself as treasurer of the Institute. He was born in St. Paul, Minn., May 7, 1883; graduated from Columbia University in 1896, with an E.E. degree. Since 1914 Professor Slichter has been an active member of 17 Institute committees and has represented the Institute on 4 joint bodies; is now a member of 7 committees and a representative on 3 bodies. A full biographical outline was published on p. 56 of Electrical Engineering for January 1931.

Bancroft Gherardi
to Receive Edison Medal

Bancroft Gherardi (A'95, F'12, and past-president) vice-president and chief engineer, American Telephone & Telegraph Company, has been awarded the A.I.E.E. Edison Medal for 1932 "for his contributions to the art of telephone engineering and the development of electrical communication." Actual presentation of the medal will take place during the forthcoming A.I.E.E. winter convention to be held in New York, January 23–27, 1932.

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of 24 members of the Institute.

Since its establishment in 1904, the medal has been awarded to the following eminent engineers and scientists: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, Frank Conrad, and Edwin W. Rice, Jr.

Mr. Gherardi was born in San Francisco, Calif., April 6, 1873. His degrees are B.Sc., Polytechnic Institute of Brooklyn 1891; M.E., Cornell 1893; and M.M.E., Cornell 1894. Upon completion of his studies at Cornell University, he entered the employ of the New York Telephone Company under John J. Carty, who was then chief engineer. From 1900–06 he was chief engineer of the New York and New Jersey Telephone Company; 1906–07 assistant chief engineer of the New York Telephone Company; 1907–18 engineer of plant, American Telephone & Telegraph Company. In 1918 he became acting chief engineer and shortly afterward chief engineer of the latter company. Since 1920 he has been vice-president and chief engineer of the American Telephone & Telegraph Company. He is a director of the Michigan Bell Telephone Company, the Cuban American Telephone & Telegraph Company, the 195 Broadway Corporation, and the Bell Telephone Laboratories, Inc.

Mr. Gherardi's activities in the Institute have been many. He was a manager 1905–08 and 1914–17; vice-president 1908–10; president 1927–28; member at various times of many committees, including the executive, Edison Medal, finance,

BANCROFT GHERARDI

headquarters, public policy, research, and constitutional revision. He has represented the Institute upon the board of trustees of the United Engineering Trustees, Inc., the Library Board, the National Research Council, the U.S. national committee of the International Electrotechnical Commission, the John Fritz Medal board of award, and other bodies, having served as president of the United Engineering Trustees, and as chairman of the John Fritz Medal board of award. He is at present chairman of the A.I.E.E. public policy committee, a representative of the Institute upon the John Fritz Medal board of award, and the board of directors of the American Standards Association; he has been president of the latter organization during the past 2 years.

In addition to his Institute activities Mr. Gherardi is vice-president and director of the Planning Foundation of America; a trustee of Cornell University; a member of the joint general committee of the Bell Telephone System and the National Electric Light Association; a member of the joint general committee of the Bell Telephone System and the American Railway Association; and chairman of the American Committee on Inductive Coordination.

Mr. Gherardi's entire professional and business career has been devoted to the art of communication. Coming into this field when the telephone art was very young (300,000 telephones in 1895) he has played a most important part in the development and perfection of operating practices and in the development of methods, equipment, and apparatus, which have brought telephone communication to the high state of perfection in which it is found today. He has directed the development and introduction of many new and improved arrangements which are in use today on a large scale, and which have added greatly to the speed and accuracy of local and long distance telephone service. His broad vision as to the place of communication, not only in the affairs of the people of the United States but also in world affairs, and his initiative and skill in the development of engineering and operating organizations and in the development of the art generally have contributed enormously to the growth and success of present day communication.

Mr. Gherardi is the author of numerous important contributions to the technical press, including the publications of the A.I.E.E. His other memberships include the American Society of Mechanical Engineers; the Franklin Institute; the New York Electrical Society; and Sigma Xi. In 1923 the Emperor of Japan conferred upon him the emblem of the Fourth Order of the Rising Sun.

G. Ross Henninger (A'22, M'27), since October 1930, associate editor for the A.I.E.E., has become its editor, effective January 1, 1933. In Institute and allied affairs he has been active for more than 11 years. He was one of the organizers and was first chairman (1921) of the Student Branch at the University of Southern California; has served on various Pacific Coast convention committees (1925–30); served the San Francisco Section successively as member of the executive committee, secre-

G. R. HENNINGER

tary, and vice-chairman from which post he resigned when he went to New York. He is a member of the Engineers' Club of San Francisco; was twice chairman of its entertainment committee. Mr. Henninger was born in Hamilton, Ohio, May 22, 1898; attended the public schools of Ocean Park, Venice, and Santa Monica, Calif.; graduated from the Venice high school in 1916; received the degree of Bachelor of Science in electrical engineering from the University of Southern California, Los Angeles, with the class of 1922, after the completion of extra-curricular work in the fields of civil engineering and business administration. During his university career he was a full-time employee of the Southern California Edison Company, Ltd., serving in the company's operating department as a

substation and power house night shift operator. Upon graduation, he entered (Feb. 15, 1922) the student course of the Westinghouse Electric & Manufacturing Company in East Pittsburgh, Pa., subsequently becoming a member of the relay section of the company's supply engineering department where he spent a year in laboratory, office, and field work in connection with the development, design, and application of protective relays for electric power systems and associated equipment. Leaving the employ of the Westinghouse company, Mr. Henninger reentered (Oct. 1, 1923) the services of the Edison company as operating assistant to the electrical protection engineer, in which position he was charged with responsibility for the satisfactory operation of protective relay equipment throughout the company's system. On December 1, 1924, Mr. Henninger left the Edison company to go to San Francisco, Calif., as engineering editor of the then *Journal of Electricity* (which subsequently changed its name to *Electrical West*) the Pacific Coast publication of the McGraw-Hill Publishing Company, Inc. In that position he developed and was in responsible charge of the technical department of the magazine until he left, September 30, 1930, to go to Institute headquarters in New York.

L. L. Elden (A'03, M'13) technical advisor to the operating vice-president of the Edison Electric Illuminating Company of Boston, Mass., has retired after being associated with that company and its predecessors since 1885. Doctor Elden was born in Buxton, Maine, in 1868. For many years he had been in charge of the design, construction, and operation of the entire electrical system of the company. He has had consulting duties in connection with all departments of the company. Recently he has devoted much time to problems of standardization, interconnection, regional supply, transmission and distribution, appliance motor performance in relation to system regulation, economics of off-peak water heating, and international electrical affairs. He has been responsible for the invention of several devices in connection with the operation of public utility systems and has contributed many articles to technical magazines. He is a member of the National Electric Light Association, the Association of Edison Illuminating Companies (past-president 1918), American Standards Association, National Fire Protection Association, The International Electrotechnical Commission, and the World Power Conference Committee. In 1928 he was awarded the honorary degree of doctor of science by Tufts College.

R. E. Doherty (A'16, M'27) has been appointed dean of the new engineering college of Yale University, New Haven, Conn. Organization of this new engineering college to take over the engineering division of Sheffield Scientific School of Yale University is announced elsewhere in this issue. Professor Doherty was for many years consulting engineer of the General Electric Company, Schenectady, N. Y., resigning this position in the summer of 1931 to become professor of electrical engineering at Yale University, as announced in Electrical Engineering for June 1931. Upon the retirement of Prof. C. F. Scott (HM'29 and past-president) it is expected that Professor Doherty will become chairman of the department of electrical engineering, as well as dean of the college. A personal item briefly outlining the achievements of Professor Doherty was given in Electrical Engineering for September 1932, p. 672.

C. R. Hayes (A'03, M'20) formerly engineering manager of Charles H. Tenney & Company, Boston, Mass., has been appointed general superintendent of the Fitchburg (Mass.) Gas and Electric Light Company. The engineering department of the Tenney organization will continue under the direction of F. C. Sargent (A'04, F'12) vice-president in charge of engineering with headquarters in Boston, Mass.

G. P. Daiger (A'31) who received the degree of doctor of engineering at The Johns Hopkins University, Baltimore, Md., in June 1932, is now connected with The Hoover Company, North Canton, Ohio. Doctor Daiger's dissertation was upon eddy current shielding and the measurement of resistivity.

A. R. O'Clare (A'29) formerly with the Sperry Gyroscope Company as service engineer on stabilizers for yachts, is now handling engineering supplies for all kinds of marine equipment and repairs under the name of the O'Clare Marine Electric Company. He is distributor for Charles Cory and Company for the state of Florida.

A. E. Kennelly (A'88, F'13 and past-president) professor emeritus of electrical engineering at Harvard University, Cambridge, Mass., has been elected to the presidency of the International Scientific Radio Union (Union Radio Scientifique Internationale, or U.R.S.I.) to succeed the late Général Gustave A. Ferrié.

J. B. Clapp (A'24) formerly sales engineer for the Copperweld Steel Company, New York, N. Y., is now district representative for the James R. Kearney Corporation, St. Louis, Mo., his territory including the eastern half of Pennsylvania, all of New Jersey, Delaware, District of Columbia, and Maryland, and a portion of West Virginia.

J. G. Burley (A'28) who previously has been assistant laboratory engineer, Hydro-Electric Power Commission laboratories, Toronto, Ontario, Can., is now in the C.N. division plant department of the Bell Telephone Company of Canada, at Toronto.

O. W. Bartlett (A'30) formerly assistant electrical engineer of the Fraser-Brace Engineering Company, Ltd., Montreal, Quebec, Can., is now commercial engineer with the Ernest Turner Electrical Instruments, Ltd., Chiltern works, High Wycombe, Bucks, England.

W. W. Garstang (A'31) is now vice-president and chief engineer of Electronic Laboratories, Inc., Indianapolis, Ind. Mr. Garstang previously was field engineer for P. R. Mallory and Company at Indianapolis. He has been responsible for the design of several vibrating type eliminators.

H. J. Blackhall (A'30) is now president of Blackhall and Company, Essen, Germany. While in this country Mr. Blackhall held the position of checker in the development engineer's office of the Western Electric Company, Kearny, N. J.

Otto Naef (A'23, M'31) who at one time was consulting engineer for the American Brown Boveri Company, Inc., Camden, N. J., has recently become chief engineer of the circuit breaker division of Ateliers de Construction Oerlikon, Zurich, Switzerland.

J. B. Fisken (A'03, M'13, F'13) consulting engineer, The Washington Water Power Company, Spokane, Wash., continues his long time efforts as chairman of the accident prevention committee of the engineering section of the Northwest Electric Light & Power Association.

G. B. Pulham (A'18, M'27) recently chief erection staff engineer for India, Burma, and Ceylon for Metropolitan-Vikers Electrical Company, Ltd., Calcutta, India, has now returned to Auckland, New Zealand.

J. R. Sontagh (A'26) has recently been appointed mechanical design engineer for the RCA-Victor Company, Inc., Camden, N. J. Mr. Sontagh formerly was development engineer for the Western Electric Company, Inc., Chicago, Ill.

S. C. Tanner (A'29) formerly engineer with R.C.A. Communications, Inc., Bolinas, Calif., has recently become engineer in the valuation department of the Pacific Gas and Electric Company, San Francisco, Calif.

J. E. Yates (A'15) assistant chief engineer of Pacific Power & Light Company, Portland, Ore., has been appointed chairman of the hydraulic power committee of the Northwest Electric Light & Power Association.

O. L. LeFever (A'10, M'21) general superintendent of the Northwestern Electric Company, Portland, Ore., has been appointed chairman of the prime movers committee of the Northwest Electric Light & Power Association.

G. E. Quinan (A'18, F'18) chief electrical engineer, Puget Sound Power & Light Company, Seattle, Wash., has been appointed

to serve the Northwest Electric Light & Power Association as chairman of its power systems engineering committee.

H. V. Schreiber (A'03, M'13) safety engineer with the Capital Traction Company, Washington, D. C., was recently appointed chairman of the program committee of the National Safety Council.

F. W. Marshall, Jr. (A'28) formerly engineer in the power department of the Texas Power & Light Company, Dallas, Texas, is now a member of the firm of Marshall and Sewell, engineers at Dallas.

Walter Rebmann (A'27) formerly with the Southern Cities Utilities Company, Philadelphia, Pa., is now connected with Sweetzer, Sheppard, and Deakin, Philadelphia, Pa.

Obituary

John Joseph Carty (A'90, M'03, F'13, HM'28) past-president (1915–6) member for life, and long an active leader in Institute affairs, died December 27, 1932 at the John Hopkins Hospital, Baltimore, Md., just as this issue was going to press. A biographical sketch will appear later.

Clarence Sherman Hammatt (A'93, M'23, and Member for Life) state engineer, State of Florida, died recently in his home city, Jacksonville, Fla. He was born in 1858 at Geneseo, N. Y. Following business college he took a special course of lectures on illuminating engineering at The Johns Hopkins University. Mr. Hammatt had long been an outstanding figure in Florida engineering circles, and it is stated that he was the oldest member of the Institute in point of service in the Florida Section. Mr. Hammatt went to Florida in 1883. In 1887 he became connected with the Jacksonville Water Works, acting for a time as chief engineer, later in the same year becoming superintendent and chief engineer of the Citizens Gas and Electric Company and the American Illuminating Company in Jacksonville. He held these positions with both companies for 10 years, until the gas and electric companies were separated, at which time he became superintendent and manager of the Jacksonville Electric Company. When this company was sold to the Street Railway Company 2 years later he undertook an electric supply and contract business, known as the Florida Electric Company, continuing as vice-president of this company until 1908. During 1910 and 1911 he was superintendent of the Ware County Electric, Gas, and Ice Company in Georgia, following which for 3 years he owned and operated an ice plant at Mildale, Fla. Starting in 1914, he was for many years president of the Consolidated Engineering Company. For some 20 years he has been consulting engineer for the board of commissioners of state institutions of the state of Florida. He was president or secretary-treasurer of the Florida state board of engineering examiners for a number of years following the enactment of the state law in 1917. During 1922, he was president of the (national) State Board of Engineering Examiners. He was a charter member of the Florida Engineering Society (past-president 1921–22). He was also a member of The American Society of Mechanical Engineers, and of the Society of American Military Engineers; during the World War he was a member of the U.S. national board for naval defense. He was a lieutenant-governor of the Sons of the Colonial Wars in Georgia, and a member of the Sons of the American Revolution.

Solomon David Benoliel (A'96) president and general manager of the International Chemical Company, Philadelphia, Pa., died November 23, 1932. Mr. Benoliel was born in New York, N. Y., in 1874. He received his bachelor's degree from the College of the City of New York, an electrical engineering degree from the School of Mines of Columbia University, and the degree of master of arts from the School of Pure Science of Columbia University. Between 1896 and 1897, he was engaged in general engineering work, following which for 4 years he was assistant professor of electrical engineering, physics, and chemistry at Adelphi College. Between 1901 and 1906 he was with the Roberts Chemical Company (now Niagara Alkali Company) Niagara Falls, N. Y., as electrochemical engineer and general manager. He then became general manager, consulting expert, and later president and general manager of the International Chemical Company. He was a lecturer of the board of education, New York, N. Y., and the Brooklyn Institute of Arts and Sciences, between 1899 and 1901. He was the inventor of many scientific cleaners and lubricants for industrial uses, and contributed several articles on engineering subjects. Mr. Benoliel was a member of the American Chemical Society, the American Electrochemical Society, the American Electro-Platers Association, the Franklin Institute, and the American Association for the Advancement of Science. He was treasurer, president, or director of several building and loan associations. He was a member of the Penn Athletic Club and the Engineers' Club of Philadelphia.

George Porter Baldwin (A'00) vice-president of the General Electric Company, New York, N. Y., in charge of activities connected with steam railroad electrification, died of pneumonia December 7, 1932, in New York, after an illness of only a few days. He was born in San Francisco, Calif., in 1874, and graduated from Leland Stanford University in 1893 with the degree of bachelor of arts in electrical engineering. He was then connected for 2 years with the Oakland Transit Company, Oakland, Calif., and the Pacific Power Company, San Francisco, as engineer. He was then for 2 years engineer for the Falk Company of Milwaukee, Wis., in their Pacific Coast department. He was in the employ of the Stanley Electric Company at the time when that organization was bought by the General Electric Company in 1903, and he then became vice-president of the Blaisdell Company of Los Angeles, where he remained until he was made manager of the Pittsburgh, Pa., office of the General Electric Company in 1910. In 1915 he became manager of the Atlantic district of the company with headquarters in Philadelphia, Pa. Mr. Baldwin was made manager of the merchandise department of the company when it was created in 1923. In 1925 he became a vice-president of the company with headquarters in New York. He was a member of the Bankers' Club, Engineers' Club, and University Club of New York, N. Y., and a member of the Greenwich Country Club.

Charles Franklin Medbury (A'11) manager of the Montreal office of the Canadian Westinghouse Company, Ltd., died recently. He was born in Foxboro, Mass., in 1867. Mr. Medbury was in the class of 1888 at Brown University, and took a course at the Thomson Houston Electric Company's factory at Lynn, Mass. He then spent 4 years with the Thomson Houston company as general salesman. In 1893 he joined the Westinghouse Electric & Manufacturing Company as manager, being in charge of several district offices since that time. He also has been manager of the Montreal office of the Canadian General Electric Company. Following this he held positions in several offices of the Westinghouse company, and in 1909 he was transferred to Montreal as manager of the office in that city, retaining this position until the time of his death. Mr. Medbury was a member of the executive committee of the Canadian Electrical Association, 1930–32.

Fred D. Smith (M'32) engineer with the United Light and Power Engineering & Construction Company, Davenport, Iowa, died December 5, 1932, from a stroke of apoplexy. He was born in 1878, graduating from the University of Illinois with the degree of batchelor of science in 1905. Between 1905 and 1907, Mr. Smith was connected with the Illinois Traction Company in Danville and Champaign, Ill., engaged in building plants and car-barns. From 1907 to 1908 he was with the Arnold Company, Chicago, Ill., engaged in a valuation of the Chicago street railways and arc lighting system. Between 1909 and 1922 he was sales engineer for the McGraw Company in Omaha, Neb., and Sioux City, Iowa, and between 1922 and 1925, was chief engineer of the Continental Gas and Electric Corporation at Omaha and Lincoln, Neb. From 1926 to the time of his death he was engineer with the United Light and Power Engineering & Construction Company.

Fred Mitchell Laxton (A'04, M'13) president of Tucker and Laxton, Inc., Charlotte, N. C., died on October 3, 1932.

Mr. Laxton was born at Morganton, N. C., in 1875, and attended the University of North Carolina. Between 1897 and 1899 he was in the shops and testing department of the General Electric Company at Schenectady, N. Y., and between 1899 and 1902 was engineer and salesman for the company in the supply, lighting, and railway departments. In 1902 he became manager of the Atlanta supply department remaining in this position until 1905. For a number of years following this he was engaged in the design and construction of electric plants. Between 1905 to 1908 he was president and manager of the Electric Manufacturing Company, Atlanta, Ga., and since 1908 has been president and manager of Tucker and Laxton, Inc.

John J. L. Manning (A'12) assistant engineer in the electrical engineering division, department of power, Boston Elevated Railway, Boston, Massachusetts, died November 30, 1932. He was born in Charlestown, Mass., in 1890. Following graduation from a post-graduate course at Boston Mechanic Arts High School in 1909, he graduated from the electrical course of Sewell Institute, and attended night courses at the Massachusetts Institute of Technology, Cambridge. Mr. Manning had been in the employ of the Boston Elevated Railway Company since 1910. He had a varied experience in testing, drafting, designing, and construction of power generation and distribution equipment.

H. F. L. J. Seyler (A'29) electrical testman, Consolidated Gas, Electric Light & Power Company of Baltimore, Md., died from an accident December 4, 1932. Mr. Seyler was born in 1905 in York, Pa. His technical education was obtained principally through night school courses at The Johns Hopkins University, Baltimore. From June to December 1923, he was helper in the electrical construction department of the Pennsylvania Water and Power Company. From 1925 until the time of his death he held the position of testman in the electrical testing department of the Consolidated Gas, Electric Light & Power Company.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Anderson, F. C., 741 Oak Ave., Westfield, N. J.
Carlsen, O. Grag, 635—72nd St., Bklyn., N. Y.
Chen, C. Mayo, 18 An Check L8, Scott Rd., Shanghai, China.
Florez-Estrada, Jose, Avenida De La Paz 60, Reparto Alture-Rio Almendares, Marianao, Havana, Cuba.
Heiser, Edwin S., 413 Federal Bldg., St. Paul, Minn.
Jefferson, H. F., 633 Portola Ave., Glendale, Calif.
Katz, Henry, 2714 Wallace Ave., New York, N. Y.
Keller, Dr. Max Leo, Kornweg 8, Aarau, Switzerland.
Kirby, F. M., 22 E. 40th St., New York, N. Y.
Lutz, Robert S., 24 Brooke Ave., Rochelle Park, N. J.
Newman, Rexford C., 100 High St., St. Clairsville, Ohio.
Nimetz, John B., 3442 Sacramento St., San Francisco, Calif.
Peterson, Alex., Central West Pub. Serv. Co., Omaha, Neb.
Pool, Russell P., 209 S. Kenilworth, Oak Park, Ill.
Schatz, Nathan, 1845—52nd St., Brooklyn, N. Y.
Thornton, George C., P.O. Box 904, Birmingham, Ala.

Local Meetings

Future Section Meetings

Boston

January 10—International Communication.
February 14—Mercury Turbine.

Cleveland

January 19—Social meeting.
February 16—Communications.

Detroit-Ann Arbor

January 17—at Michigan Bell Auditorium. Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc.

February 14—at Detroit Edison Auditorium. Hydroelectric Development and Its Present Status in the Industry, by E. M. Burd, The Consumers Pwr. Co.

Fort Wayne

January 17—at Home Tel. & Tel. Auditorium. Dial Controlled Robots, by H. M. Bruckart, Home Tel. & Tel. Co.; A New Development in Oven Control, by R. M. Hartigan, Gen. Elec. Co. Inspection of the Fort Wayne Telephone Exchange.

February 14—at Chamber of Commerce Auditorium. Travel in the Orient, by Dr. W. K. Hatt, Purdue Univ.

Lehigh Valley

January 13—at Necho Allen Hotel, Pottsville, Pa. Electric Welding, by Col. Royal Mattice, Mattice Engg. Co.

Pittsfield

January 17—Modern Railway Electrification: With Special Reference to Pennsylvania System, by J. V. B. Duer, Pennsylvania RR. Co.

February 7—Magic of the Ages, by Dr. Harlan Tarbell.

February 21—Applied Genetics: Directed Evolution, by Dr. Hubert Goodale.

Toledo

January 13—Air Conditions, by H. B. Matzen, Carrier Corp.

Toronto

January 13—Coordination of Insulation, by W. W. Lewis.

January 27—Astronomy and the Dunlap Observatory, by Prof. Chant, Univ. of Toronto.

February 10—Speaker—Dr. J. O. Perrine.

February 24—Air Conditioning.

Past Section Meetings

Akron

Behind the Scenes, by W. L. Enfield, Genl. Elec. Co. Dinner. Nov. 10. Att. 40.

Baltimore

A New Line of Low Voltage Circuit Breakers, by H. J. Lingal, Westinghouse Elec. & Mfg. Co. Dinner. Nov. 18. Att. 75.

Birmingham

New Frontiers Through Research and Engineering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Nov. 11. Att. 45.

Boston

Exploring the Universe, by Donald Menzel, Harvard Univ. No. 15. Att. 350.

Chicago

Electron Tubes for Power Applications, by C. W. Stone, Genl. Elec. Co. Power Group Meeting. Nov. 15. Att. 225.

Electrified Coal Mining, by Carl Lee, Peabody Coal Co. Joint meeting with Western Soc. of Engrs. Nov. 21. Att. 85.

Cincinnati

General Lighting—Plus, by W. E. Conley, Genl. Elec. Co. Illus. Joint meeting with Cincinnati Elec. Club. Nov. 17. Att. 75.

Cleveland

Science, Politics, and Engineering, by L. A. Hawkins, Genl. Elec. Co. Joint meeting with Cleveland Engg. Soc. Nov. 17. Att. 361.

Connecticut

International Telephone Service, by Dr. H. S. Osborne, Am. Tel. & Tel. Co. Nov. 22. Att. 59.

Dallas

The Contribution of Telephone Research to Talking Motion Pictures, by Dr. J. O. Perrine, Am. Tel. & Tel. Co. Nov. 14. Att. 298.

Denver

Use of Electrical Apparatus in Geophysical Prospecting, by J. H. Wilson. Illus. R. H. Owen, Station KOA, exhibited the latest equipment in 5 meter sending and receiving apparatus. Dinner. Nov. 18. Att. 36.

Detroit-Ann Arbor

Power Switch Gear, by S. M. Dean, Detroit Edison Co. Dinner. Nov. 15. Att. 75.

Erie

American Institute of Electrical Engineers, by W. H. Pelton, Erie Lighting Co.; Technical Federation of Erie, by George Bach, Union Iron Works; The Engineer, by M. C. Goodspeed, Genl. Elec. Co. Oct. 19. Att. 50.

Electric Welding, by E. W. P. Smith, Lincoln Elec. Co. Nov. 11. Att. 40.

Florida

Progress Through Research and Engineering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Nov. 7. Att. 60.

Fort Wayne

Utility Management Problems, by C. V. Sorenson, Indiana Serv. Corp. Illus. Dinner. Nov. 15. Att. 75.

Houston

New Engineering Developments in Generation, Transmission, and Distribution, by I. T. Monseth, Westinghouse Elec. & Mfg. Co. Nov. 29. Att. 105.

Indianapolis-Lafayette

The Diverter Pole Generator, by E. Darwin Smith, Elec. Products Co. Illus. Nov. 18. Att. 26.

Iowa

Photoelectric Cells and Their Applications in Industry, by R. H. Maxwell, Westinghouse Elec. & Mfg. Co. Demonstrations. Nov. 17. Att. 91.

Lehigh Valley

The Unseen Conductor, by Glen Appleman, Pa. Pwr. & Lt. Co. Nov. 18. Att. 130.

Los Angeles

Progress in Architectural Acoustics, by Dr. V. O. Knudsen, Univ. of Calif. Illus. Dinner. Nov. 15. Att. 60.

Louisville

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Dinner. Nov. 14. Att. 65.

Lynn

Healing With Electric Fever, by C. F. Tenney, 5th Ave. Hospital, New York, and A. B. Page, Genl. Elec. Co. Nov. 17. Att. 400.

Memphis

Electric Wiring as Applied to the Home, by E. W. Mann. Nov. 15. Att. 28.

Milwaukee

Operation of Electric Machines in Various Media, by C. J. Fechheimer. Demonstrations. Joint meeting with Engrs. Soc. of Milwaukee. Dinner. Oct. 19. Att. 175.

The Marvels of Electricity, by Oscar Werwath, Milwaukee Schl. of Engg. Dinner. Nov. 2. Att. 450.

The Engineer and the Law, by A. Kannenberg, Pub. Serv. Comm. Joint meeting with Engrs. Soc. of Milwaukee. Dinner. Nov. 16. Att. 125.

Minnesota

History of Electrical Meter Development, by K. J. Mertz, Northern States Pwr. Co.; Automatic Synchronizing, by Perry Peterson, Genl. Control Corp. Nov. 29. Att. 20.

Montana

Some Physiological Effects of Electricity, by Prof. C. F. Bowman, Montana State Col. Nov. 16. Att. 30.

Nebraska

Uses and Distribution of Natural Gas, by A. D. Almquist, A.S.M.E. student; Air Conditioning in Home, by J. Steele, A.S.M.E. student; Thyratron Demonstration, by L. W. Cooke and P. Ehrenhard, A.I.E.E. students; Cooperation, by Ernest Hartford, asst. secy., A.S.M.E. Inspection trips. Dinner. Joint meeting with A.S.M.E. Branch and Nebraska Sections of A.I.E.E. and A.S.M.E. Nov. 14. Att. 100.

Effect of Electric Shock on the Human System, by E. L. McQuiddy, Univ. of Nebraska. Joint meeting with Omaha Engrs. Club. Nov. 30. Att. 105.

New York

Transportation by Air. Speakers: E. E. Wyman, Pan-American Grace Airways, Inc., and P. R. Bassett, Sperry Gyroscope Co. Nov. 9. Att. 200.

Street Lighting and Street Accidents, by R. E. Simpson, Travelers Insurance Co.; The Value of Street Lighting to the Community, D. M. Diggs, Genl. Elec. Co. Nov. 15. Att. 75.

Rectifiers and Electronic Devices. Speakers: C. A. Butcher, Westinghouse Elec. & Mfg. Co., and W. S. Hill, Genl. Elec. Co. Nov. 29. Att. 600.

Niagara Frontier

Executive and membership committee meeting. Nov. 3. Att. 10.

Geology of Western New York, by N. F. Snyder, Link Belt Co. Nov. 17. Att. 55.

North Carolina

Theory and Design of High Voltage Insulators, by A. O. Austin, Ohio Insulator Co.; Aluminum and the Electrical Industry, by F. L. Magee, Aluminum Co. of Amer.; Some Interesting Facts, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Short talk by Prof. W. E. Freeman, vice-pres., A.I.E.E. Elec. of officers: F. L. Moser, chmn.; G. F. Stratton, secy.-treas.; R. F. Everest, E. A. Kilburn, and R. S. Fouraker, exec. committee. Nov. 4. Att. 140.

Philadelphia

Safe Harbor Hydroelectric Development, by R. L. Thomas, Pa. Water & Pwr. Co. Nov. 14. Att. 235.

Pittsburgh

Micarta, by H. H. Ashinger; Micarta in Industry, by H. W. Reding; Micarta—A Modern Decorative Material, by D. R. Dohner; all of Westinghouse Elec. & Mfg. Co. Nov. 15. Att. 205.

Pittsfield

Air Conditioning—Design and Application of Equipment, by D. W. McLenegan, Genl. Elec. Co. Dinner. Nov. 15. Att. 170.

Rovings of a German Sea Raider, by Capt. J. Lauterbach. Dec. 6. Att. 1400.

Portland

System Analysis by Means of Direct Current Calculating Table, by John Bankus, Genl. Elec. Co.; Domestic Applications of the Heat Pump, by C. McLean, Northwestern Elec. Co.; An Economical Machine for Winding Electric Heater Coils, by C. J. Scoville, Genl. Elec. Co. Joint meeting with Oregon State Col. Branch. Nov. 22. Att. 74.

Inspection trip to the Camas mill of the Crown Willamette Paper Co. Nov. 26. Att. 35.

Rochester

Analogies Between Radio and Photographic Techniques, by B. V. K. French, United Am. Bosch Corp. Illus. Joint meeting with Inst. of Radio Engrs. Nov. 14. Att. 145.

St. Louis

Television, by Dr. J. O. Perrine, Am. Tel. & Tel. Co. Joint meeting with Engrs. Club. Nov. 17. Att. 1000.

San Antonio

Recent Floods in Devil's River and Damage to Central Power & Light Company's Plants, by C. L. Dowell and M. H. Lovelady, both of Central Pwr. & Lt. Co. Nov. 21. Att. 46.

San Francisco

Experimental Methods of Atomic Disintegration, by Prof. E. O. Lawrence, Univ. of Calif. Nov. 16. Att. 280.

Saskatchewan

Nature's Time Table and Measuring Rods, by R. J. Brandon. Nov. 4. Att. 28.

Schenectady

Engineering Factors in the Economic Problem, by R. E. Flanders, Jones and Lamson Machine Co. Joint meeting with A.S.M.E. Sec. Nov. 3. Att. 165.

The Battle of the Alchemists, by Dr. K. T. Compton, pres., Mass. Inst. of Tech. Nov. 18. Att. 700.

K. K. Stowell, editor, Architectural Forum, presented an illustrated lecture showing both practical and radical designs which are being proposed for fabricated houses both here and abroad. Joint meeting with A.S.M.E. Sec. Dinner. Dec. 6. Att. 150.

Sharon

New Utility Given Large Capacity Rectifiers by Sectionalizing, by A. L. Atherton, Westinghouse Elec. & Mfg. Co. Illus. Film—"The Story of the Fabrication of Copper." Nov. 15. Att. 125.

Southern Virginia

Extending Our Frontiers Through Engineering and Research, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Nov. 2. Att. 240

Springfield

Interconnection, by C. W. Mayott, Connecticut Valley Pwr. Exchange. Illus. Nov. 14. Att. 106.

Syracuse

The Great Protector—Safeguard for Illumination of Street and Highway, by D. M. Diggs, Genl. Elec. Co. Nov. 7. Att. 178.

Toledo

Impressions of Conditions in Europe, by Mr. Duernberger, Wagner Elec. Corp. Nov. 2. Att. 16.

Ralph Eide, Ohio Bell Tel. Co., and D. Kelly explained the purpose and work of the Industrial Rehabilitation Committee. Nov. 4. Att. 350.

Executive committee meeting. Nov. 6. Att. 9.

The Fundamentals of Direct Current, by F. C. Helwig, Toledo Edison Co.; Power Tubes, Their Development and Uses, by C. W. Stone, Genl. Elec. Co. Nov. 18. Att. 125.

Toronto

Standards, by Prof. J. F. MacDonald, Univ. of Toronto. Joint meeting with A.S.M.E. Sec. Nov. 10. Att. 125.

Some Notes on Modern Relay Protection, by E. M. Wood, Hydroelectric Pwr. Comm. Nov. 25. Att. 120.

Utah

Eugene Pack, chief engr., station KSL, gave a description of the new 50-kw transmitter, after which he conducted an inspection trip through the new transmitter building. Nov. 14. Att. 40.

Past Branch Meetings

University of Alabama

Armature Reaction, by S. Gross and F. Livingston, students; Television, by O. Collins, student; Vocational Guidance, by E. Appoloni and R. Barn, students. Nov. 7. Att. 31.

Film—"X-Rays." Nov. 14. Att. 108.

Eyes Seeing Beyond the Horizon, by O. Collins, student. Nov. 28. Att. 21.

Discussion. Dec. 5. Att. 31.

University of Arizona

Development of the Vacuum Tube From the Triode to the Pentode, by R. Carson, student. Sept. 30. Att. 6.

The Photoelectric Cell and Its Applications, by J. Jones, student. Oct. 14. Att. 8.

The Bushing Type Current Transformer, by B. Watkins, student. Oct. 28. Att. 8.

B. Watkins, student, continued his paper The Bushing Type Current Transformer. Nov. 4. Att. 7.

University of Arkansas

The Operation of the Oscillograph, by C. L. Mowery; Talking Light Beam, by Frank Davis, students. Dec. 1. Att. 45.

Armour Institute of Technology

The Use of Carrier Currents in Telephone and Telegraph Communications, by Mr. Aubuchon, Am. Tel. & Tel. Co. Nov. 18. Att. 40.

University of British Columbia

Hydroelectric Power Development at Shuswap Falls, by H. Sladen; Television by A. C. Tregidga; Sound Recording, by S. Carre, all students. Oct. 27. Att. 32.

Transmission of Photographs Over Telephone Wires, by F. Bolton; Stage Lighting, by H. Tull; Microphones, by T. Mouat, all students. Motion pictures. Nov. 17. Att. 15.

Bucknell University

Water Development of the Safe Harbor Project, by D. Zanella, student; Radio Problems Aboard a Ship, by S. L. Windes, student; The Holtwood and West-Port Substations, by Prof. G. A. Irland, counselor. Nov. 3. Att. 11.

University of California

Stanford A.I.E.E. Meeting and High Voltage Demonstrations at Ryan Laboratory, by K. F. Serkland; Measuring Time Lags of Sparkovers, by A. Tilles; Personal Experiences After Leaving College, by C. F. Dalziel, all students. Oct. 27. Att. 22.

Nominations of officers. Nov. 15. Att. 15.

Executive committee meeting. Nov. 9. Att. 6.

Election of officers: P. C. Nelson, chmn.; R. Tibbetts, secy.; L. Sepmeyer, vice-chmn.; W. Roy, treas. Nov. 30. Att. 86.

Catholic University

Rectifiers, by J. Springmann, student; Radio Broadcasting, by Dr. T. J. MacKavanagh, counselor. Nov. 11. Att. 15.

X-Rays, by Mr. Hengstler, student. Dec. 7. Att. 14.

Clemson Agricultural College

The Safe Harbor Hydroelectric Development, by F. W. Edwards; Corona Tube Voltage Regulator, by H. M. Rodgers, students. Nov. 29. Att. 42.

Colorado Agricultural College

The Use of the Photoelectric Cell in Industry, by Harold Inman; Electrochemistry, by L. Preston, students. Nov. 14. Att. 12.

The Dial Telephone System, by L. Alexander; Electric Signs, by H. Chinburg, students. Nov. 28. Att. 14.

University of Colorado

The Rise and Fall of Samuel Insull, by E. C. Sparrow, student. Nov. 2. Att. 49.

Mint Service, by F. E. Shepard, U. S. Mint. Joint meeting with A.S.M.E. branch. Nov. 16. Att. 90.

Cooper Union

Election of officers: J. B. Watkins, pres.; H. T. DiGiovanni, vice-pres.; Harry Kihn, secy.; R. A. Wylie, treas. Nov. 15. Att. 30.

Drexel Institute

Inspection trip to the new 50-kw transmitting station of WCAU. Oct. 19. Att. 50.

Lamp Manufacture, by C. R. Sager, Westinghouse Elec. & Mfg. Co. Nov. 16. Att. 15.

Reading Railroad Electrification, by E. Pastoret, Reading RR. Co. Dec. 7. Att. 20.

Duke University

Talks by R. L. Peppell and A. H. Werner, students. Nov. 15. Att. 20.

University of Florida

Gas Filled Tubes in Industry, by Prof. S. A. Sashoff. Nov. 8. Att. 37.

Manufacturing Courses Offered Undergraduates by Electrical Companies, by A. S. Hay, student; Treatment of Accidents Due to Electricity, by K. S. Rizk, student. Films—"Resuscitation" and "Pillars of the Sky." Nov. 22. Att. 23.

Georgia School of Technology

Talk by H. D. Woodward, Am. Tel. & Tel. Co. Oct. 12. Att. 44.

Address by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Nov. 10. Att. 100.

Harvard University

A Radio Controlled Yacht, by R. H. Packard, student. Demonstrations. Oct. 27. Att. 27.

The Electrification of the Lackawanna Railroad, by E. L. Moreland, Jackson & Moreland. Nov. 9. Att. 55.

University of Idaho

Picnic. Nov. 4. Att. 42.

A Year Spent at the California Institute of Technology, by J. H. Johnson, counselor. Nov. 10. Att. 31.

Iowa State College

Barbecue. Oct. 12. Att. 100.

History of the Incandescent Lamp, by Richard Allbright, student. Oct. 25. Att. 22.

University of Iowa

Film—"The Benefactor." Nov. 9. Att. 29.

Development of the Microphone, by D. Duckett, student; Radio City of New York, by L. Grizel, student. Nov. 23. Att. 30.

Television, by Thomas Cox, Northwestern Bell Tel. Co. Nov. 30. Att. 32.

University of Kansas

Talks by students who attended the Conference on Student Activities held at the Univ. of Okla. Nov. 17. Att. 36.

The Emmett Mercury Vapor System, by E. S. Post, student; Advantages of Belonging to a Technical Society, by N. Downes, student; Electrolysis of Copper, by Roy Yates, student; Human Engineering, by R. Battle. Joint meeting with A.S.M.E. Branch and Kansas City Sections of A.I.E.E. and A.S.M.E. Dec. 1. Att. 130.

University of Kentucky

Prof. W. E. Freeman, vice-pres., A.I.E.E., Univ. of Kentucky, discussed the advantages of membership in the A.I.E.E. Nov. 2. Att. 39.

Address by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc. Nov. 14. Att. 51.

Louisiana State University

Film—"Modern Manufacturing by Stable Arc Welding." Dec. 8. Att. 23.

Marquette University

Turbo-Electric Carferrys of the Pere Marquette Steamship Company, by G. Griffith, student. Nov. 3. Att. 22.

Joint meeting with A.S.M.E., A.S.C.E., and A.I.Ch.E. Entertainment and moving pictures. Dec. 1. Att. 180.

Michigan State College

Film—"The Greater Campus." Nov. 16. Att. 26.

The Safe Harbor Hydroelectric Development, by G. H. Kempfer; The Photoelectric Cell, by R. G. Mueller; A. A. Kunze, R. T. Thompson, and L. J. Samppala related experiences while employed at various times; all students. Nov. 30. Att. 18.

University of Michigan

The Mercury Vapor Boiler, by J. R. MacIntyre, student. Film—"Power." Nov. 17. Att. 34.

Milwaukee School of Engineering

Modern Methods of Arc Welding, by K. L. Hansen, Harnischfeger Corp. Illus. Nov. 9. Att. 111.

University of Minnesota

Western Electric Sound Equipment, by E. Miller, student. Mr. Simmons, Western Elec. Co., gave a talk pertaining to his profession. Nov. 17. Att. 125.

Mississippi State College

Motion pictures. Nov. 15. Att. 50.

Missouri School of Mines and Metallurgy

The Historic Pearl Street Generating Station, by R. Borchers, student. Mr. Bronison, Missouri Utilities Co., discussed the possibilties of securing work in the electrical field after graduation. Nov. 16. Att. 24.

University of Missouri

The Brown Meter, by H. Goodrich, student. Dec. 7. Att. 30.

Montana State College

The Life and Work of Thomas A. Edison, by W. H. Flanze; Double Conductors for Transmission Lines, by J. Garrison; Night Lighting for Outdoor Sports, by J. W. Gilmer; Dial Service for Small Communities, by M. Hilden; Some Uses of Electricity in Medicine, by K. Hufford; Pranks of Electric Arcs, by D. Hyde; Rock Island Hydroelectric Development, by O. Johnson; Colored Luminous Steam, by J. M. Kennedy, all students. Nov. 3. Att. 100.

Electrical Operation on the Great Northern, by F. Liquin; Organizing the Silent Salesman, by H. E. Murdock; Spokane School Teaches Industry a Lesson, by L. Peterson, all students. Nov. 10. Att. 83.

University of Nebraska

Demonstration of television. Nov. 15. Att. 30.

Joint meeting with A.S.M.E. Branch and Nebraska Sections of A.I.E.E. and A.S.M.E. (Complete report under "Past Section Meetings.") Nov. 14. Att. 100.

Newark College of Engineering

The Work of the Institute, by H. H. Henline, acting national secretary, A.I.E.E.; What G. E. Expects of Its Engineers, by L. Cummins, Genl. Elec. Co. Nov. 7. Att. 33.

Power Rates, by S. A. Moore, Pub. Serv. Elec. & Gas Co. Nov. 28. Att. 14.

University of New Hampshire

Film—"Power Transformers." Nov. 5. Att. 18.

Injuries From Electric Shock, by J. P. Sikoski, student; Panama Canal and Its Electrification, by H. T. Dickson, student. Demonstration of resuscitation used at the Genl. Elec. Co., by Prof. W. B. Nulse. Nov. 12. Att. 29.

Antennas, by J. P. Ring; How the Autogiro Flies, by P. C. Thomas; students, X Y Z Stands for Transpositions, by L. H. Hitchcock, counselor. Nov. 26. Att. 28.

University of New Mexico

Mr. Chester Russell, Jr., nominated for counselor. Nov. 9. Att. 8.

College of the City of New York

Aeronautics and Electrical Engineering, by C. F. Green, Gen. Elec. Co. Illus. Nov. 3. Att. 50.

Inland Terminal No. 1, by P. L. Gerhardt, Port of N. Y. Authority. Joint meeting with A.S.C.E. Branch. Nov. 10. Att. 50.

Sweep Circuit for Cathode Ray Oscillograph, by C. Macon, student. Illus. Nov. 17. Att. 40.

New York University

Applications of the Photoelectric Cell, by Mr. Zdanowitz; Push-Pull Amplifiers, by Mr. Christie; Visible Sound and Audible Light, by Mr. Delmonte, all students. Nov. 11. Att. 20.

Quadrangle, by Mr. Delmonte; Electric Aids to Aviation, by Mr. Lobo; Measuring Projectile Velocity by Electricity, by Mr. Schmidt; Scrambled Speech, by Mr. Och, all students. Dec. 2. Att. 20.

North Carolina State College

Film—"The History and Manufacture of the Incandescent Lamp." Nov. 15. Att. 84.

Reports of the Student Conference, held at the University of Tennessee, were given by F. E. Brammer, L. G. Atkinson, Jr., and Wm. Boyd, students. Dec. 6. Atti. 40.

University of North Carolina

Film—"Mazda Lamps Preferred." Nov. 14. Att. 16.

North Dakota State College

Discussion. Nov. 3. Att. 16.

Film—"Electric Heating in Industry." Joint meeting with A.S.C.E. Branch. Nov. 17. Att. 38.

University of North Dakota

Thyratrons and Their Applications, by Mark Scarff, student; Precision Frequency Measurements, by Wm. Denk, student. Nov. 16. Att. 12.

Standard Electrical Units, by John Winsness, student; Hipernik—A New Metal Alloy, by Edward Shields, student. Nov. 30. Att. 16.

University of Notre Dame

Arc Welding, by J. Dulin, student. W. D. Stamm, Twin Branch Pwr. Plant, explained the operation of this plant. Refreshments. Nov. 16. Att. 45.

Teletypewriter Service, by E. Butler, student. Distribution and Sales Promotion as Applied to the Engineer, by J. J. Moffet, Westinghouse Elec. Co. Nov. 30. Att. 50.

Ohio State University

First Aid and Methods of Resuscitation, by Carl Cramer, student. Nov. 10. Att. 22.

Ohio University

Film—"Electric Heat in Industry." Nov. 16. Att. 18.

Oklahoma A. & M. College

Economics of Rural Line Distribution, by B. E. Lowe, student. Motion pictures. Oct. 17. Att. 47.

Arc Welding, by Prof. E. D. Soderstrom. Oct. 31. Att. 20.

University of Oklahoma

Relations between Power and Telephone Companies in Community Distribution, by E. B. Jennings, Southwestern Bell Tel. Co. Nov. 17. Att. 46.

Oregon State College

Prof. E. C. Starr, counselor, outlined the benefits of membership in the A.I.E.E. A Brief History of the Telegraph, by H. M. Johnson, student. Nov. 10. Att. 31.

University of Pittsburgh

Applications of Diesel Engines to Power Stations, by A. L. Schwartz; Design of D-C Field Coil for D-C Motors, by J. F. McClenahen, students. Oct. 28. Att. 106.

Australia and the Tropics, by S. Q. Hayes, Westinghouse Elec. & Mfg. Co. Motion pictures. Nov. 3. Att. 93.

Princeton University

A. S. Bickham, student, discussed vacuum tube operation as class A and class B amplifiers. Nov. 16. Att. 12.

Purdue University

The Electric Eye in Industry, by O. H. Caldwell, editor, Electronics. Nov. 15. Att. 150.

Rensselaer Polytechnic Institute

Rural Electrification, by D. E. Blandy, N. Y. Pwr. & Lt. Co. Nov. 15. Att. 105.

Rhode Island State College

Cathode-Ray Television, by Wm. Downes, student. Nov. 10. Att. 28.

Film—"Power." Dec. 2. Att. 30.

Rutgers University

Life of Steinmetz, by H. Anderson, student; Life of G. Marconi, by E. Shearer, student. Nov. 22. Att. 16.

Mercury Arc Rectifiers, by Mr. Munch, student. Nov. 29. Att. 16.

University of Santa Clara

A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E., outlined recent research work and development of circuit breakers by Dr. J. Slepian. Joint meeting with A.S.M.E. Branch. Nov. 3. Att. 53.

Discussion. Nov. 13. Att. 19.

University of South Carolina

Discussion. Nov. 7. Att. 17.

The Dawning of the Age of Alloys, by J. R. Hopkins; Lightning Proof Transmission Lines, by F. Griffith; Electric Welding Repairs Waterwheel Runners, by G. V. Hendrix, all students. Nov. 14. Att. 34.

Mystery Rags That Cure Disease, by W. R. Humphlett; Auto Radio Problems Face Solution in 1933, by C. C. Jones; Bombarding the Atom for Power and Gold, by H. Howard, all students. Nov. 21. Att. 32.

Discussion. Nov. 28. Att. 21.

Induction Motors, by Prof. A. C. Carson. Dec. 5. Att. 32.

South Dakota State School of Mines

POWER DISTRIBUTION, by Mr. Rand, Dakota Pwr. Co. Nov. 17. Att. 18.

Southern Methodist University

Presentation of paper on A-C GENERATORS AND SYNCHRONOUS MOTORS. Illus. Dec. 7. Att. 11.

Stanford University

F. P. Copley described his experiences while a student in Germany. Dr. J. S. Carroll, and Bradley Cozzens, Bureau of Pwr. & Lt., gave short talks about the work at Ryan Lab. Joint meeting with the San Francisco Sec. Oct. 19. Att. 200.

Inspection trip through the central offices of R. C. A. Communications, Inc. Oct. 29. Att. 21.

RADIO PROBLEMS, by Harold Elliott, student. Nov. 17. Att. 20.

Syracuse University

RADIO CRYSTALS, by D. Grigson, student; AIRPORT ILLUMINATION, by J. Y. Howard, student. Nov. 15. Att. 23.

LIFE OF STEINMETZ, by H. R. Kelso, student; PHOTOELECTRIC RELAYS, by H. J. Klotz, student. Nov. 23. Att. 23.

MERCURY ARC RECTIFIERS, by J. Mayo, student; APPLICATIONS OF HEAVISIDE'S CALCULUS TO ELECTRICAL PROBLEMS, by E. Pharo, student. Nov. 29. Att. 23.

JOSEPH HENRY, by Wm. Moriarty, student; MICHAEL FARADY, by P. Nevaldine, student. Dec. 6. Att. 23.

Swarthmore College

Election of officers: J. H. Walton, pres.; A. C. Holman, secy.-treas. Nov. 10.

Texas A. & M. College

VELOCITY TYPE MICROPHONE, by T. L. Hiner, student. Nov. 10. Att. 32.

THE A. &. M. COLLEGE MESS HALL EQUIPMENT, by W. L. Pharo, student. Dec. 1. Att. 34.

Texas Technological College

THE ARTHUR S. HUEY MEMORIAL GENERATING STATION, by Walter Cox, student. Nov. 8. Att. 31.

University of Vermont

RESEARCHES IN ARC WELDING, by D. King, student. Sept. 28. Att. 9.

Motion pictures. Oct. 12. Att. 43.

THE MODERN TELEPHONE HANDSET, by D. W. Jenks, student. D. C. Whitney elected secy. Oct. 26. Att. 9.

Discussion by G. W. Patterson, student. Nov. 9. Att. 9.

Inspection trip. Nov. 16. Att. 10.

THE CATHODE RAY TUBE, by D. C. Whitney, student. Nov. 23. Att. 8.

Virginia Polytechnic Institute

SOUND ECHOING APPARATUS, by E. N. Henry; THE USE OF ELECTRICITY IN THE MEDICAL PROFESSION, by J. P. Giles, students. T. E. Gilhooley, student, described how the Lynchburg Foundry Co. had modernized its Rodford plant. Nov. 3. Att. 30.

THE TELEPHONE HANDSET, by W. H. Johnson; THE USE OF PHOTOELECTRIC CELLS IN INDUSTRY, by A. F. Proffit; PROTECTIVE DEVICES FOR RADIO TRANSMITTERS, by R. W. McCorkle; ELECTRICAL INSULATION PAPER, by J. E. Kulm; THE PENNSYLVANIA RAILROAD ELECTRIFICATION, by W. F. Marcuson, all students. Nov. 10. Att. 49.

Film—"Nature's Frozen Credits." Nov. 17. Att. 53.

THE U.S. UTAH MOBILE TARGET, by J. S. Jarvis; THE MOST EFFICIENT POWER PLANT IN THE U.S., by A. DeVillasante; THE COPPER OXIDE PHOTOELECTRIC CELL, by M. H. Hudson, all students. Dec. 2. Oct. 25.

State College of Washington

THE PROBLEMS ENCOUNTERED IN THE CHANGE OVER FROM D-C TO A-C POWER IN THE CITY OF SPOKANE, by H. H. Schoolfield, Washington Water Pwr. Co. Oct. 28. Att. 25.

Motion pictures. Nov. 11. Att. 40.

University of Washington

Inspection trip to the North Skagit substation of the City Light Dept. Nov. 3. Att. 25.

Film—"Around the World With the Graf Zeppelin." Nov. 10. Att. 75.

STREET LIGHTING, by Mr. Burnham, Nepage McKenny Co. Nov. 15. Att. 20.

ELECTRICITY IN PLANT GROWTH, by G. Cushing, Puget Sound Pwr. & Lt. Co. Dec. 1. Att. 15.

Washington University

Discussion. Dec. 1. Att. 24.

EXPLOSIVES, by F. Rohne, student; DEVICES TO AID IN THE CALCULATIONS FOR ELECTRICAL PROBLEMS, by P. Crowley, student. Dec. 6. Att. 20.

Employment Notes

Of the Engineering Societies Employment Service

Positions Open

A manufacturer of a guaranteed article which is particularly adapted for introduction by engineers, desires distributors. It is stated that a distributor can develop a business with this article, starting from a small beginning and with practically no capital; it has tremendous sales possibilities; it offers exceptional profits to the distributor and large savings to the user. W-4312.

Men Available

Appraisal

SWITCHGEAR COMMERCIAL ENGR, experienced in appraisals, cost-estimating, pricing and specification-writing. Familiar with genl. industrial and central station practice. 1926 E.E. grad, 1 yr G. E. test course, single, 29. Now available. Salary open. D-1005.

Construction

GENL SUPT., elec, 37, married. Grad. E.E., 13 yr experience in the utility field, particularly in engg, construction, maintenance and operation of distribution and transmission substations. Desires position with large industrial concern or operating company with responsibility of their electrical system. B-2885.

ASSOC. E.E., 35, married, tech. education, desires position with utility. Exceptional ability in underground transmission experience. Location, immaterial. Available on short notice. D-278.

PRACTICAL ELEC CONSTR. CHIEF, 32, single. Desires work in construction willing to travel anywhere; 14 yr practical experience in the construction, maintenance and operation of industrial plants and mines. Last 4 yr in Latin America. Speaks Spanish and German fairly well. Available immediately. Location immaterial. C-2101.

Design and Development

E.E., tech. grad., 32, married. Twelve yr experience in design of steam and hydroelectric pwr. stations, substations, and industrial plants, including estimates, costs, specifications, purchase of equipment, drafting, and construction supervision. Desires position with utility, engg, or industrial concern. References. New England preferred, but will consider other location. C-9715.

DESIGN ENGR, E.E. univ. grad., 1927, thoroughly experienced in design, test and application of outside plant hardware, 4 yr experience in Bell Tel. Lab., desires position in design or teaching. Salary and location open. D-1305.

MECH. ELEC ENGR, 33, with 13 yr experience in mech. design and varied shop practice including 4 yr on the Cornell Univ. faculty, desires work of any kind at once. Salary open. D-122.

ELEC. DESIGN ENGR., 37, married, 15 yr experience, elec circuit and equip. layouts for industrial, commercial, and pwr. plant installations. Capable of preparing complete plans, specifications, estimates and make all studies and calculations to meet the most exacting light and power requirements. Five yr experience, supervisory position. Location, East. C-292.

E.E., grad., 30, single, 2 yr additional study in accounting, 5 yr Westinghouse experience on elec and mech. design, development, lab., mfg. on fans and fractional hp motors. Miscellaneous experience on elec wiring of buildings, drafting, and commercial engg. Need work at once. New England preferred. D-580.

E.E. for design, development, or research in illumination and elec measurements, but will consider any line or location. B.S. and M.S. in E.E. from Univ. of Wis. Westinghouse Engg. School. Experience with well-known elec testing lab. in all kinds of elec testing. Available now. Single. C-8875.

Executives

E.E., 36, married, 8 yr experience supervising design lighting and pwr. control on industrial plants, refineries, office buildings, etc.; 4 yr pwr. house and substation engg. Desires position with industrial organization preferred. Exec. and constructive consciousness. Location in the East. C-5412.

E.E., S.B., M.E.E., 17 yr experience. Good knowledge of accounting. Past 10 yr with gas and elec utility in mgmt. end, with particular reference to utility rates. Desires position as rate consultant to utility or large commercial or industrial concern. B-248.

PATENT ATTORNEY, mech. and elec engr. Registered in the U.S. since 1921 and in Canada since 1927. Metropolitan district only. Moderate salary. B-6941.

ELEC SERVICE-ENGR, 41, 20 yr experience. Design, construction of pwr. plants, substations, distribution systems, industrial plants. Rebuilding, rewinding of large pwr. equip. such as turbo-generators, rotary-converters, motors, etc. Extensive experience, dismantling, rebuilding large transformers. Travelled 10 yr, service-engr for leading elec concern of the U.S. B-8055.

GRAD INDUSTRIAL ENGR, 35, married, post-graduate work; 12 yr experience in factory mgmt. and production methods in plants located in various sections of country. Desires position as plant mgr. or supt. with industrial firm interested in mgmt. systems. Capable of handling men and production. References. Available immediately. B-6876.

E.E. GRAD., R.P.I., 35, married. Experience with mfg. elec control apparatus and in elec design of hydro and steam pwr. stations and industrial plants. Has specialized on switchboard, wiring, and control problems. At present studying modern theory of pwr. distribution and also electronic devices. B-6274.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St., San Francisco — 205 West Wacker Drive, Chicago — 31 West 39th St., New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

E.E., grad. Cornell U. '23. Qualified to direct all activities of elec utility operating division. Familiar with organization and equip. necessary for economical operation, maintenance, development and customers' serv. Age 33, married. C-5155.

E.E. GRAD., Ohio State, 1929, married, 27. Three yr experience with pwr. co. including training in all depts. and 1 yr as jr. substation test engr. Best of references. Available immediately. Location immaterial. D-1767.

GRAD. ENGR., 31, 10 yr experience specializing in transmission and distribution problems for mgmt. utility in both foreign and domestic field. Experience includes design and construction of low voltage networks, industrial electrification, overhead and underground distribution systems, also valuation, genl economics, budgetary control and reorganization problems. B-6934.

E.E., 33, married, desires position, mfr. of radio or pub. address systems, broadcasting station, or carrier dept. of elec pwr. co.; 4 yr design, construction, operation, testing of equip. for elec pwr. stations; 6 yr installation, wiring, testing radio broadcast, tel. and tel. repeaters and carrier equip. Excellent references. D-733.

E.E. GRAD., 35, married; 3 yr westinghouse course in elec lab. practice; 3 yr development and production of mercury vapor rectifier auxiliaries; 2 yr development of low-pwr. consumption relays. Desires responsible position in elec lab. or as engr on devpt. of small apparatus. Available at once. Middle West preferred. D-1769.

E.E., B.S. in E.E. Iowa State Col. 1929, 32, single, worked way through col. Three yr group leader, Westinghouse transformer test, including pwr., distr., and instrument transformers, a-c welding outfits, special apparatus. Liberal shop experience. Interested, exec. position, supervision, design and constr., inspection and testing. References. Location immaterial. Available immediately. D-1081.

GRAD. E.E., married, 13 yr design, construction and operation of pwr. plants, transmission lines, substations and distribution systems. Reports. studies and calculations of a highly tech. nature. For 4 yr was asst. to the elec engr of large engg firm. B-9401.

E.E., Univ. Grad., 30, single, 6 yr experience in pwr plant and industrial plant design, drafting, specification writing, construction, operation, and maintenance. Also experienced on pwr. substations and underground and overhead distribution systems. Excellent references. D-1766.

ELEC. CONSTR. ENGR, 44, married; 20 yr experience, design, construction, and maintenance, Diesel oil plants, ry. automatic substations and distribution and genl utility work. Location preferred, South West but anywhere acceptable. Available on short notice. C-8520.

Instruction

E.E. GRAD., Rutgers Univ., 27, single, with 3 yr teaching experience in E.E. Phi Beta Kappa.; $2^1/_2$ yr practical experience with W.E. & M. Co.; $1^1/_2$ yr spent in design a-c and d-c motors and generators. Available immediately. Any location. D-1758.

E.E. GRAD., 33; 10 yr practical and maintenance experience before graduation; 1 yr teaching in high school, and 2 yr experience with cons. engg firm after graduation. C-8633.

Junior Engineers

E.E., grad. of Armour Inst. of Tech., 26, single; $2^1/_2$ yr experience in distribution engg. Desires e.e. work of any type with a future. Location preferred east or middle West. Available immediately. D-403—3813-Chicago.

YOUNG GRAD., 25, would desire any type of a position with a utility or engg firm. Has 5 yr engg and utility deg., and is available at once. Location immaterial. D-1608.

CORNELL GRAD. E.E. '31, M.E.E. '32, 23, single. Major in communication. Good scholastic record. Desires work preferably on telephone radio or sound equip. Salary immaterial. Available immediately. D-1709.

E.E. GRAD., Rensselaer, 1932, 22, single, Sigma Xi, athlete. Job with utility or mfg. concern in field of pwr. preferred. Location and salary immaterial. Available at once. D-1716.

JR. ENGR., 23, B.A. Amherst, to complete requirements for S.B. and S.M. in E.E. at M.I.T. in Feb. Twelve months' experience in Bell system. Looking for opportunity and hard work. References available. Welcome N. Y. or Boston interview or correspondence anywhere. D-1726.

B.S. in E.E. GRAD., Duke U., 1932, 21, single. Desires engg work, preferably pwr. house work. Some experience in civil engg also. References available. D-1731.

B.S. in E.E., V. P. I., 1931. Honor student, Phi Kappa Phi, 27, single. Completed first year of advanced course in engg of G. E. Co.; 1 yr G. E. test. Switchboard construction work and series st. ltg. experience. Available immediately. Location immaterial. D-1739.

ENGR., 26, married, E.E., R.P.I., '30 (honor group), Westinghouse student course, engg school and mech. design school. Experience: elec installation, circuit breaker engg, and air conditioning. Available immediately. Location immaterial. D-1738.

UNIV. OF FLORIDA, 1932 grad., B.S.E.E., 24, single. Good character, willing to work; 3 summers watthour meter work with utilities; 1 summer inventory pwr. lines. Desire elec engg work except sales. Available immediately. Location immaterial. D-1734.

B.S., M.S. in E.E., cooperative course, M. I. T. 1932, 22, single. Good scholastic record. Short experience at G. E., machine shop, on test, and research lab. Aggressive, willing, capable of assuming responsibility. References available. Location immaterial. Available immediately. Salary secondary. Interested, any position which requires engg background and which offers a future. D-1511.

E.E. GRAD., 1931, Rensselaer Poly. Inst., 23, single. Thirteen months' experience as follows: 2 months' tracer, 2 months' shop electrician, 9 months' draftsman and tester. All with mfr. of heavy mchg. Desires type of employment where training and experience will be advantageous. Location immaterial. Available immediately. D-1770.

E.E. GRAD., 1930, 24, Sigma Xi, $1^1/_2$ yr grad. study, $1^1/_2$ yr devpt. and experimental work with fans and fan type motors, specializing in induction motors. Location immaterial. Available immediately. D-1771.

GRAD. E.E. 1929, M.S. in E.E., 1932; 27, single. G. E. test experience. Desires anything in engg. Salary and location secondary. Available at once. C-9003.

B.S. in E.E. 1932, Armour Inst. of Tech., 23, single. Six months' experience building special radio production test equip. Several yr radio service. Good knowledge radio theory and practice. Excellent scholastic record in all subjects. Desires any kind of work in elec field, radio job preferred. Location immaterial. Available now. D-1765.

Maintenance and Operation

REPAIR AND MAINTENANCE ENGR, 47, married. Am. Univ. E.E. grad. Five yr practical shop experience large Middle West concern; $3^1/_2$ yr actual repair, maintenance of generators, transformers and distribution lines with Am. utility co., So. Am. Speaks Portuguese, Spanish, and English. Location, no preference. Available immediately. Good references. D-1728.

CONSTR. AND MAINTENANCE, 38, married, grad. E.E.; 6 yr experience on mech. and elec pwr. equip. 9 yr layout and design of elec installations for Consumers Pwr. Co., Mich., and Commonwealth Edison Co., Chicago. Desires position as factory supt. of elec maintenance and constr. Location immaterial. Available at once. C-991.

Manufacturers' Agents

MFRS. AGT. in Mid-South wants a few high grade accounts, mchy., equip., or supplies for industries or utilities. D-1721.

Research

TECHN. GRAD., single, 10 yr experience with leading elec mfg. in the repair and testing of elec apparatus, $1^1/_2$ yr G. E. test. Desires position in testing and experimental work, motors, generators, etc. Any connection considered where experience would prove useful. Initial salary secondary to future prospects. C-8778.

B.S. in E.E. 1929, Univ. of Michigan, married, 30, 3 yr experience testing, experimenting of track circuit apparatus used in ry. signaling; made mathematical calculations on all types of track circuits. Desires research, ry. signaling or teaching position. Prepared to teach mathematics, physics, electromechanics. Available immediately. Salary and location open. D-1760.

Sales

SALESMAN, contact repr. or mfrs. agt., experienced representative, desires position with high grade co. that manufactures line of high or low tension industrial or utility equip. Eastern location preferred. B-4067.

E.E. GRAD., Rensselaer, with experience in meter dept., pwr. sales and rates dept. of large utility desires employment of any kind, any place. D-1702.

ENGR, 39, married, B.E.E. Available immediately. Experience in pwr. plant operation; 13 yr sales engr. G. E. both foreign and domestic. Wish to entertain proposition, salary or commission basis, representing small internal combustion engines, generators, switchboards, cable for complete pwr. plant application in South Western district. B-708.

GRAD. E.E., age 33. Valuable experience in engg and mgmt. with large elec utility co. and mfr. of elec equip. Also sales experience. Location immaterial. D-745.

Membership

Recommended for Transfer

The board of examiners, at its meeting of December 8, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Clarke, David D., cons. E. E., Kansas City Pwr. & Lt. Co., Mo.
Henry, Raymond T., E. E. in charge of design, Buffalo, Niagara & Eastern Pwr. Corp., Buffalo, N. Y.
Porter, Joseph Franklin, pres., Kansas City Pwr. & Lt. Co., Mo.
Post, Geo. G., vice-pres. in charge of pwr., Milwaukee Elec. Ry. & Lt. Co., Wis.
Roe, Ralph C., consultant for various publ. utilities, including Jersey Central P. & L. & Va. Pub. Serv., N. Y. City.

To Grade of Member

Font, Manuel, E. E., Pub. Serv. Comm., San Juan, Porto Rico.
Gill, Murray F., genl. supt., Phoenix Util. Co., Allentown, Pa.
Johnson, Alek, asst. E. E., Interborough Rapid Transit Co., N. Y. City.
Krupy, Alex. J., planning engr., Commonwealth Edison Co., Chicago, Ill.
Manbeck, Park D., advisory engr., Natl. Carbon Co., Inc., Cleveland, Ohio.
Skiff, Warner M., mgr., Nela Park Engg. Dept., Genl. Elec. Co., Cleveland, Ohio.
Stanka, Erhardt W., 26 Oak St., Belleville, N. J.
Zehr, Geo. A., elec. engg. asst., Buffalo, Niagara & Eastern Pwr. Corp., Buffalo, N. Y.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Jan. 31, 1933.

Abramson, R. J., c/o E. Edelemann & Co., Chicago, Ill.
Adams, W. C., 801 South Lynn St., Champaign, Ill.
Aldape, V. C., Cia de Tranvias, Luz & Fuerza Motriz de Monterrey, Medidores de Luz, Monterrey, N. L., Mexico.
Allen, R. B., Windsor, Mo.
Atwood, A. W. Jr., 331 S. Menton Ave., Pasadena, Calif.
Babloosian, L. M., 776 N. Cass St., Milwaukee, Wis.
Batcheller, J. R., 187 E. 55th St., Portland, Ore.
Beckmann, H. P., 130–52 120th St., South Ozone Park, L. I., N. Y.
Behn, V. B., Bureau of Standards Washington, D. C.
Bellah, L. T., Southern Bell Tel. & Tel. Co., Charlotte, N. C.
Benjamin, L. J., 341 Riverdale Ave., Bklyn., N. Y.
Berens, W. F., 1217 Mass. Ave. N. W., Washington, D. C.
Betzler, H. W., N. Y. Steam Corp., N. Y. City.
Billings, E. J., (Member) Babcock & Wilcox Co., N. Y. City.
Bogstahl, M., Shell Eastern Petroleum Products Inc., N. Y. City.

Bolton, S. W., Commonwealth of Pa. Dept. of Highways, Pittsburgh.
Booth, C. V., Univ. of Fla., Gainesville.
Breitwieser, C. J., United Sound Productions Co., Los Angeles, Calif.
Bretholl, C. F., Duke Pwr. Co., Charlotte, N. C.
Brinton, W. T., Flagstaff Elec. Lt. Co., Flagstaff, Ariz.
Brous, J. C., Richmond, Kansas.
Brown, C. T., Lafayette Col., Easton, Pa.
Brown, G. S., Mass. Inst. of Tech., Cambridge.
Bruce, W. D., Bklyn. Edison Co., Bklyn., N. Y.
Buchak, K., 534 S. 33rd St., Omaha, Neb.
Buck, F., North Dakota St. Col., Fargo.
Burbank, J. H., 49 Sparhawk St., Amesbury, Mass.
Bushnell, H. C. Jr., 1215 E. 28th St., Bklyn., N. Y.
Calberg, G. P., 23 Fernleaf Ave., Longmeadow, Mass.
Campbell, G. C., 269 1st Ave., Salt Lake City, Utah.
Carson, R. W., Westinghouse Electric & Mfg. Co., Newark, N. J.
Chamberlain, B. R., Southern Bell Tel. & Tel. Co., Charlotte, N. C.
Chamberlain, G. J., 4970 Vista Pl., San Diego, Calif.
Chanon, H. J., General Electric Co., Cleveland, Ohio.
Cioffi, P. P., (Member) Bell Telephone Laboratories, New York, N. Y.
Clark, H. S., 63 Grove St., Passaic, N. J.
Cooper, F. W., University of Colorado, Denver, Colorado.
Croft, W. H., Industrial Pwr. Equip. Co., Baltimore, Md.
Danner, C. E., Route e, Box 230, Kent, Wash.
Daun, G. T., 125 Portage Ave., Sault St. Marie, Mich.
Davidson, J. La F., Jr., United Electric Lt. & Pwr. Co., New York, N. Y.
Di Meo, S., 1537 S. Chadwick St., Phila., Pa.
Dove, B. M., 321 W. 94th St., N. Y. City.
Dyer, J. M. Jr., 222 C Ave., Waurika, Okla.
Easton, E. C., Lehigh Univ., Bethlehem, Pa.
Ehringhaus, E. E., 828 Graydon Ave., Norfolk, Va.
Emery, W. F., Univ. of Colo., Boulder.
English, L. L., Cazenovia Gas & Oil Co., N. Y.
Erickson, J. E., Michigan State Highway Dept., Bergland.
Estlin, F. E., Canadian Genl. Elec. Co., Ltd., Regina, Sask., Can.
Evers, G. E., 99 Pilling St., Bklyn., N. Y.
Feeney, M. L., 5642 Kenmore Ave., Chicago, Ill.
Fay, E. E. Jr., 522 E. Third St., Fremont, Neb.
Fernsler, G. L., Phila. Storage Battery Co., Pa.
Ferris, R. M., III, New York Telephone Co., New York, N. Y.
Fischer, F. P., Milford, Pa.
Forster, A. G., R.C.A. Communications, Inc., Bolinas, Calif.
Fritz, B. R. (Member), Dept. of Electricity, City of Alameda, Calif.
Fussell, L. Jr., 451 Riverview Ave., Swarthmore, Pa.
Garrett, W. A., Am. Tel. & Tel. Co., Denver, Colo.
Glover, C. A., Texas State Highway Dept., Ozona.
Goldstein, M. K., 1701 E. Lanvale St., Baltimore, Md.
Gorton, W. G., 16 Gregnough St., Brookline, Mass.
Graves, W. K., Potomac Electric Power Co., Washington, D. C.
Gray, C. M., 608 Tuscaloosa Ave., Birmingham, Ala.
Haas, G. P., Bell Tel. Co., Cleveland, Ohio.
Handy, J. C., Westchester Ave., Ellicott City, Md.
Hart, H. C., University of Pennsylvania, Philadelphia, Pa.
Hayes, H. H., Onida, S. D.
Headley, F. B., 432 Court St., Reno, Nev.
Heaton, H. T., 1903 Seventh Ave., Troy, N. Y.
Hoffman, G. L., Consolidated Gas, Elec. Lt. & Pwr. Co. of Baltimore, Md.
Huffer, C., Corydon, Ind.
Immich, H. R., Southwestern Bell Tel. Co., Topeka, Kan.
Israel, A. I. 112 Callender St., Dorchester, Mass.
Jacobs, J. W., Bethlehem Shipbldg. Corp. Ltd., Quincy, Mass.
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Jamison, D. B., John E. Brown Col., Siloam Springs, Ark.
Jennings, Oliver S., Westinghouse Elec. & Mfg. Co., Mansfield, Ohio.
Johnson, J. H., 826 43rd St., Bklyn., N. Y.
Johnson, P. K., 27 Sunapee St., Springfield, Mass.
Jones, A. W., 8823 Petoskey, Detroit, Mich.
Keep, O. A., Genl. Elec. Co., Erie, Pa.
Kern, R. E. (Miss), 444 Kenwood Rd., Drexel Park, Pa.
Klinck, R. W., Univ. of B. C., Vancouver, B. C., Can.
Komerska, F. J., Karlin, Mich.
Kruger, H. C., 469 25th Ave., San Francisco, Calif.
LaGraff, F. E., Clarkson Col. of Tech., Potsdam, N. Y.
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Lawyer, H., Okla. Gas & Elec. Co., Okla. City.
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Lebert, A. W., Dublier Condenser Corp., Bronx, N. Y. City.
Leone, W., Bklyn. Edison Co., Bklyn., N. Y.
Lerz, O. M. Jr., United Elec. Lt. & Pwr. Co., N. Y. City.
Lev, S. N., 420 N. Maine Ave., Atlantic City, N. J.
Levy, F. E., Univ. of Calif., Berkeley.
Lewis, W. J., Cincinnati St. Ry. Co., Ohio.
Ligon, W. D. (Member), 641 Washington St., N. Y. City.
Locke, H. E., 1760 E. Clay St., Decatur, Ill.
Love, H. B., 5287 24th St., Detroit, Mich.
Loye, E. S., Univ. of Minn., Minneapolis.
Lund, G. V., 740 Langdon St., Madison, Wis.
Lusby, W. S., 5438 Cedar Ave., Phila., Pa.
Mace, O. E., Stemmers Run, Md.
Macoy, E. W., American Can Co., Maywood, Ill.
Manzi, M. H., Millbrook, N. Y.
Marofsky, H. J., Northern States Pwr. Co., St. Paul, Minn.
Marshall, M. C., 2249 Linden Ave., Long Beach, Calif.
Matson, U. A., Bell Tel. Lab., Inc., N. Y. City.
Maurer, P. H., Eclipse Machine Co., Elmira, N. Y.
McKay, W. M., Natl. Air Transport, Inc., Chicago, Ill.
Menendez, E., Univ. of Fla., Gainesville.
Miles, L. D., Genl. Elec. Co., Schenectady, N. Y.
Monlezun, M., New Orleans Pub. Serv., La.
Moore, H. R., Am. Tel. & Tel. Co., N. Y. City.
Morehead, C. W., School of Engg., Princeton, N. J.
Moss, C. E., 109 Lancaster Rd., Richmond, Va.
Mundel, A. B., 787 Crotona Park North, N. Y. City.
Mylius, R. A., Carnegie Inst. of Tech., Pittsburgh, Pa.
Neal, F. N., Univ. of Utah, Salt Lake City.
Nelson, F. J., 15 State Rd., Ashtabula, Ohio.
Nelson, P., 121 Monticello Ave., Piedmont, Calif.
Neuschaefer, G.C., 2221 Haviland Ave., Bronx, N.Y.
Nevitt, C. J., 1858 Irving Ave., San Diego, Calif.
Nixon, R. L., 838 Pine St., Camden, N. J.
O'Sullivan, F. J., Univ. of Wis., Madison.
Packtor, B. M., 125 Greenwood St., New Haven, Conn.
Paine, R. C., 436 Cornelia St., Boonton, N. J.
Pascoe, R. L., Pa. R.R. Co., N. Y. City.
Patzelt, R., 144 Burlington St., Riverside, Ill.
Pelatowski, S. M., 68 Marshall St., West Haven, Conn.
Penfold, W. E., 1049 Ainslie St., Chicago, Ill.
Peterson, P. O. Jr., Carlisle, Ark.
Pflieger, A. B., 820 E. Wells St., Milwaukee, Wis.
Pierce, J. P., N. Y. Edison Co., N. Y. City.
Piercy, W. E., 607 E. High St., Ebensburg, Pa.
Pontius, W. N., 33 Greeley St., Buffalo, N. Y.
Powers, R. E., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Preuss, J., Bklyn. Edison Co., Bklyn., N. Y.
Price, G. A., 1016 Court St., Sunbury, Pa.
Pringle, D. O., 917 Blanchard Ave., Findlay, Ohio.
Procopio, R. G., Montgomery, N. Y.
Prow, A. H., Strawbridge & Clothier, Phila., Pa.
Quigley, Q. S., P.O. Box 154, East Point, Ga.
Radford, W. H., Mass. Inst. of Tech., Cambridge, Mass.
Reeve, K. A., 105 Glen Ave., Sea Cliff, N. Y.
Reinbold, R. E., Northern States Pwr. Co., St. Paul, Minn.
Rheinhardt, M. F. Jr., 107 E. 32d St., Baltimore, Md.
Rockholt, L. R., 690 Calmar Ave., Oakland, Calif.
Rosencrans, C. A., Warwick, N. Y.
Ross, P. W., Indianapolis Pwr. & Lt. Co., Indianapolis, Indiana.
Rushmore, L. A. Jr., Long Island Ltg. Co., Roslyn Heights, L. I., N. Y.
Rutledge, O. C., The Rubbercraft Corp., New Haven, Conn.
Sargent, C. S., Puget Sound Pwr. & Lt. Co., Seattle, Wash.
Schlieder, H. A., National Paper Products Co., Carthage, N. Y.
Schroder, L. D., Univ. of Utah, Fort Douglas.
Schuck, O. H. Jr., Franklin Inst., Phila., Pa.
Schutz, E., 338 Grant St., Akron, Ohio.
Scoville, C. J., Genl. Elec. Co., Portland, Ore.
Searing, W. H., 210 Thurston Ave., Ithaca, N. Y.
Seegar, F. H., Pacific Gas & Elec. Co., San Francisco, Calif.
Seitz, R. M., Union Gas & Elec. Co., Cincinnati, O.
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Slater, T., Saskatchewan Pwr. Commission, Regina, Sask., Canada.
Smith, J. H., United Elec. Lt. & Pwr. Co., N. Y. City.
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Spencer, J. L. Jr., 403 East Main St., Salem, Ill.
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Sweatt, T. O., Lafayette Radio & Research Lab., Lafayette, Ind.
Thom, E. H., Oakley, Kansas.
Thompson, A. V., R. F. D. No. 1, Phoenixville, Pa.
Townsend, H. C., Howells, N. Y.
Tucker, E. H., Murchie Mine, Nevada City, Calif.
Turner, J. O. Univ. of Calif., Berkeley.
Valentine, W. W., Potomac Elec. Pwr. Co., Washington, D. C.
Vencill, G. J., Union Elec. Lt. & Pwr. Co., St. Louis, Mo.
Waisanen, W. F., Box 1002, Hancock, Mich.
Walker, R. E., Allentown High School, Milton, Fla.
Wallerstein, C. A., Master Auto-Elec. Serv. Co., Bklyn., N. Y.
Wegel, F. C., Title Guarantee & Trust Co., Riverhead, N. Y.
West, R. J., 806 S. Second St., Champaign, Ill.
Wilkinson, B. J., Niagara, Lockport & Ontario Pwr. Co., Olean, N. Y.
Williams, E. R., Stanton Operating Co., Pittston, Pa.
Wolfe, T. A., Anthracite Drilling Co., Elmhurst, Pa.
Worner, J. E., Indiana Bell Tel Co., Indianapolis.
Wright, J. H., 28 Copley St., Newton, Mass.
Zanoff, L., 4007 8th St. N. W., Washington, D. C.
190 Domestic

Foreign

Blangsted, W. E., Triumvirato 2351, Buenos Aires, Arg., S. A.
Greenwell, R. (Member), Pub. Wks. Dept., Bombay, Auckland, New Zealand.
Johnstone, A., Metropolitan-Vickers Elec. Co., Trafford Park, Manchester, Eng.
Kulasekharan, C. R., Corp. of Madras, Madras, India.
Lindorf, L. S., Bol. Kommunisticheskaia 7 Kv. 1, Moscow 4, U.S.S.R.
Lloyd, H. S., Metropolitan-Vickers Elec. Co. Ltd., Trafford Park, Manchester, Eng.
Moore, J. A. (Member), Posts & Telegraphs Dept., Penang, Straits Settlements.
Nason, P. E., 50th Observation Squadron, Luke Field, T. H.
Tharani, J. J., Elec. Pwr. House, Veraval, Kathiawar, Manavadar, India.
9 Foreign

Engineering Literature

Die GRÜNDUNG von MASTEN für FREILEITUNGEN und für BAHNFAHRLEITUNGEN und BAHNSPEISELEITUNGEN. By M. Süberkrüb. Berlin, J. Springer, 1932. 78 p., illus., 10x6 in., paper, 7 rm.—To replace the empiric formulas in use for calculating the foundations of transmission line poles, this book presents a mathematical formula which leads to an economy of foundation material. The mathematical development of this formula is given in full, and tables and curves are presented for practical use from which the necessary dimensions for a foundation can be obtained. The construction of foundations is also treated briefly.

Die METHODEN zur ANGENÄHERTEN LÖSUNG von EIGENWERTPROBLEMEN in der ELASTOKINETIK. (Ergebnisse der Mathematik und ihrer Grenzgebiete, Band 1, Heft 4.) By K. Hohenemser. Berlin, J. Springer, 1932. 89 p., illus., 10x6 in., paper, 10.50 rm.—This monograph first discusses the general methods of linear integral equations of the second kind and their application to the vibration of elastic bodies. It then takes up problems, such as vibration in rods, plates and frameworks, and the critical speed of shafts.

METHODS of TEST RELATING to ELECTRICAL INSULATING MATERIALS; Report of Committee D-9 on Electrical Insulating Materials. Phila., Am. Soc. for Testing Mtls., 1932. 236 p., illus., 9x6 in., paper, $1.25.—Contains the 1932 report of this committee together with all the standard specifications and methods of testing insulating materials which the Society has adopted. Several of the test methods are new, and various specifications have been recently revised.

PROTECTIVE FILMS on METALS. By E. S. Hedges. N. Y., D. Van Nostrand Co., 1932. 276 p., illus., 9x6 in., cloth, $5.00. Aims to summarize our knowledge of the theory of corrosion of metals and of the methods by which it can be prevented. The mechanism of corrosion, properties and examination of natural and artificial protective films, passivity and anodic films are first discussed, after which the practice of protective coating is considered. Accounts are given of the protection of metals by hot dipping, electroplating, spraying, cementation, painting, etc.

WIRTSCHAFTLICHE ENERGIEVERTEILUNG in DREHSTROMKABELNETZEN. By W. Speidel. Munich and Berlin, R. Oldenbourg, 1932. 113 p., illus., 10x7 in., paper, 7 rm.—Discusses the influence of various factors upon the economics of 3-phase cable networks. The influence of such factors as the form of the network, the voltage and the number of substations upon the construction and operating costs of generating and distributing electricity is examined and formulas derived for practical use. Factors affecting the economy of a plant are considered.

Industrial Notes

Large 1933 Utility Construction Program.—Standard Gas and Electric Company's preliminary construction budget for 1933 will total $12,474,753 for public utility companies in the system, according to John J. O'Brien, president of the company. The foregoing amount includes estimated expenditures of $1,501,611 to complete projects now under construction at utility properties in the Standard Gas and Electric Company system. The total preliminary budget expenditure for 1933 may be segregated as follows: electric department $8,486,406; gas department $1,869,464; other departments, $2,118,883.

Electric Shovels at Hoover Dam.—Nine Westinghouse equipped Marion electric shovels at Hoover Dam are digging the four 56-foot diameter diversion tunnels, whose combined length of 15,909 feet will sidetrack the Colorado River until the dam is partially in place. Electrical and mechanical maintenance on the shovels, including labor and supplies, is slightly more than 0.6 cent per cubic yard, and power consumption is estimated from test readings at 0.3 kw-hr per cubic yard. About 121 cubic yards (solid measure) per digging hour has been averaged, a relatively high figure since loaded trucks had to get out of the way before empty ones could back in. Individual records reached 200 cubic yards per hour and as much as 16,000 cubic yards, solid measurement, were removed from the tunnel in a day.

Marble-Card Extends Activities.—According to a recent announcement, R. H. Garrison, former general sales manager for the Universal Motor Co., Oshkosh, Wis., has become associated with the Marble-Card Electric Company, Gladstone, Mich., manufacturers of electrical machinery, as vice-president in charge of merchandise. A graduate electrical engineer of Purdue '16, Mr. Garrison's earliest training was in the General Electric organization. The company, a member of the National Electrical Manufacturers Association, has enlarged its facilities for greater production of its complete line of a-c motors up to 100 horsepower and d-c motors up to 75 horsepower.

Federal Trade Commission Reports on Utility Hearings.—The Federal Trade Commission recently submitted its annual report for 1932 before Congress. Public hearings were held during the fiscal year for six large utility groups, including many of their subsidiaries. Hearings on the other groups are to continue throughout the fiscal year of 1932–1933. Among the groups yet to be examined are Cities Service Company group, Niagara Hudson Power Corporation, Central and Southwest Utilities Company group, and United Gas Improvement Company. Field work of the entire investigation is expected to be completed during the fiscal year 1932–33. Most of the large holding company groups and a few of the smaller ones will have been taken up when the investigation is completed. Most of the principal holding, management and servicing companies in each of these groups will also have been taken up, and a number of operating companies considered.

Goulds Pumps Acquires Hydroil Corporation.—Norman J. Gould, president of Goulds Pumps, Inc., has announced the acquisition of the Hydroil Corporation, Lebanon, Ind., manufacturers of oil purifying apparatus. The Lebanon plant is being discontinued and the business and equipment transferred to the Seneca Falls plant of the Gould company. D. B. Clark, vice-president of Hydroil, and W. P. Alexander, factory and field representative, will join the Gould organization, which will continue to manufacture the Hydroil centrifugal purifying machines at Seneca Falls, with production planned to begin January 1, 1933. Goulds Pumps, Inc., is one of the oldest and best known pump manufacturing firms in the industry, and its experience in the manufacture of centrifugal pumps makes it possible to swing immediately into production of the entire Hydroil line. The units will be termed Goulds Hydroil Purifiers. In announcing the purchase, Mr. Gould said: "with the acquisition of the Hydroil concern, we have secured a product of the highest standing and widest acceptance. The use of centrifugal force has proved to be the most economical and satisfactory method yet developed for the purification of many oils used by industry. When centrifugal force is supplemented by efficient filtration, as is the case with the Hydroil machines, the apparatus is capable of purifying any oils, including transformer, switch, circuit breaker and Diesel engine oils."

A New Photocell.—Announcement is made by J. Thomas Rhamstine, manufacturer of precision electrical apparatus, 504 East Woodbridge St., Detroit, of the development of an improved, self-generating type of photoelectric cell for general application and service in the laboratory. The Rhamstine electronic cell, as it is named, is of the dry disc type and transforms light energy directly into electrical energy, without the aid of batteries or any other source of electric motor force. Tested on a direct current milliammeter reading 0 to 10 milliamperes, the cell generates from 5 to 7 milliamperes in direct sunlight. This self-generated current is always directly proportional to the light intensity. The cell measures $2^3/_8$ in. diameter and 1 in. thick. It is equipped with two connection prongs which fit the standard UX radio tube socket.

Allis-Chalmers Expands Pumping Unit Line.—The Allis-Chalmers Manufacturing Company, Milwaukee, has again enlarged its line of "SSU" motor driven single shaft, two-bearing pumping units. Three sizes have now been developed to work against heads up to 100 pounds (231' head) and above and covering a range in capacity from 30 gallons per minute to 140 gallons per minute. These pumps fill the need for high head pumps of low capacities at low cost. The pumps and motors are both built and guaranteed by the same manufacturer, eliminating divided responsibility. A single shaft is used on which to mount the motor rotor and the pump impeller. This shaft is supported by two amply sized ball bearings. This construction does away with any possibility of misalignment between the pump and the motor.

Trade Literature

Fuse Links.—Bulletin GEA-1521A, 12 pp. Describes low temperature fuse links for distribution cutouts. General Electric Co., Schenectady, N. Y.

Monel Metal.—Bulletin T-5, 8 pp. Describes engineering properties of monel metal. Development and Research Department, The International Nickel Co., Inc., 67 Wall St., New York.

Mercury Arc Rectifiers.—Bulletin C-1907-B, 16 pp. Describes mercury arc rectifiers of the sectional type, most generally used in power supply for traction systems. Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Instruments.—Leaflet. Describes newly developed moving coil, permanent magnet, D'Arsonval type meters, panel instruments, flush type. Includes voltmeters, ammeters, and milliammeters. Beede Electrical Instrument Co., 48 West Broadway, New York.

Motors.—Bulletin GEA-1191A, 54 pp. Describes high speed and low speed G-E synchronous motors ranging from 20 to 5,000 horsepower. Applications of different types of these machines in various industries are illustrated. General Electric Co., Schenectady, N. Y.

Laminated Synthetic Material.—Catalog, 40 pp., entitled "Dilecto—A Laminated Synthetic Material." Describes the manufacture, properties and uses, of which there are many in the electrical and radio field, of this material. Continental-Diamond Fibre Co., Newark, Del.

Stainless Steel.—Bulletin, 4 pp. Describes composition, method of manufacture and fabrication of Ingersoll stainless clad steel. The outer ply of any practical size or gage of stainless steel is bonded to a base of mild or carbon steel. Ingersoll Steel & Disc Co., 310 So. Michigan Ave., Chicago, Ill.

Radio Accessory and Laboratory Apparatus.—Catalog G, 174 pp. Describes a wide range of equipment including resistance devices, condensers, inductors, frequency- and time-measuring devices, oscillators, amplifiers, bridges and accessories, standard signal generators, modulation and distortion measurements, oscillographs, and filters, meters, audio-frequency and power transformers, and accessories, switches, dials, etc. General Radio Co., Cambridge, Mass.